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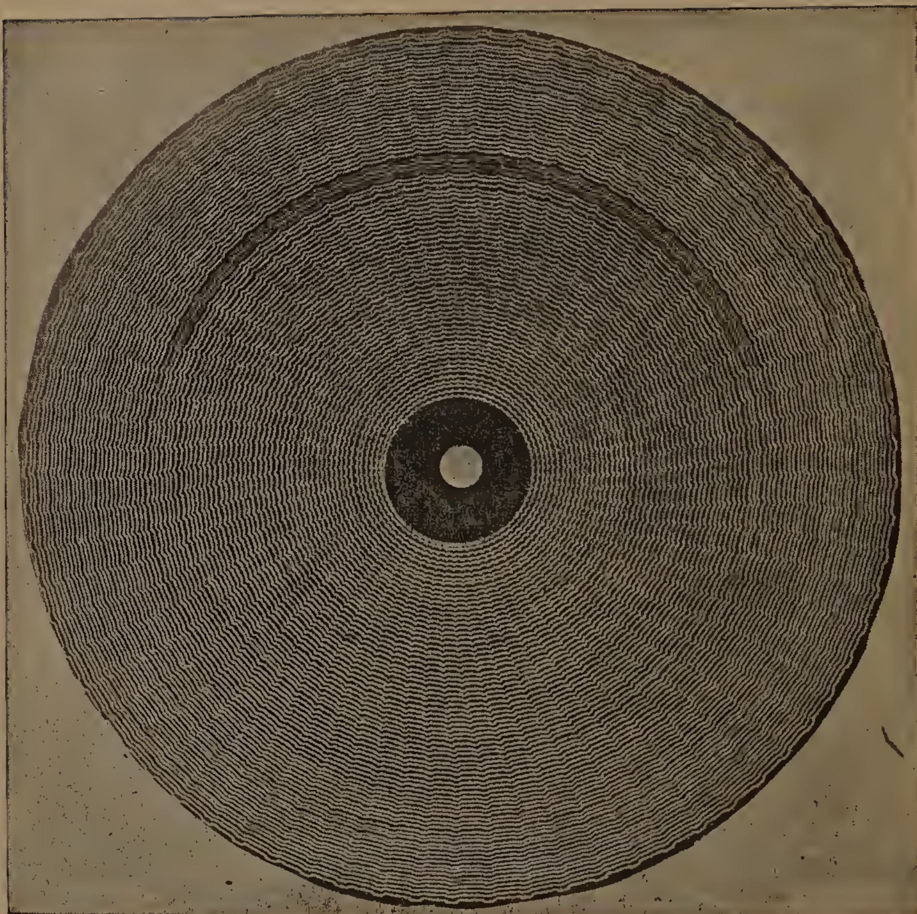

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THE PSYCHOLOGY OF MUSICAL TALENT

BY

CARL EMIL SEASHORE

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COLLEGE IN THE STATE
UNIVERSITY OF IOWA

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EDITOR'S PREFACE

The published material on methods of teaching music is of all the major subjects of instruction the scantiest. But that man is ignorant indeed who rests satisfied with the written descriptions of musical methods. Only a small fraction of this baffling field gets into print, because, of all the subjects of instruction, none has more individual "systems" of instruction and in none is there so much of the atmosphere of trade secrecy. Master teachers develop methods which are more or less original and the students of the masters come to form groups between whom there is the keenest rivalry. But, unfortunately, the methods of deciding between rival claims are too frequently argument and hostile criticism of each other.

The cause of this does not, of course, lie entirely within the personal idiosyncrasies of teachers of music, vocal and instrumental; rather is it due in great part to the imponderability of the æsthetic element in music. Interpretation and expression are not easily measured in any exact way: taste and individual differences are constituent factors in any verdict about the relative superiority of rival methods, and these have not yet been, and in all probability can never completely be, subjected to definite measurement. As a result of these conditions musical methods are in a chaotic condition without a means of separating excellence from mediocrity.

But into this unsatisfactory situation in methods of

artistry, teachers of public school music have injected into their allied field four movements which have materially benefited the subject of methods in the public schools. Three of these are the application of the aims of English composition to musical composition as a school project, the application of the methods of primary reading to the teaching of elementary music, and the introduction of the idea of the relative importance of musical appreciation in comparison with musical performance for the great majority of school children.

The fourth movement is that described and demonstrated in this volume. The author has assigned to himself during the last several years the scientific study of the psychology of musical abilities. He has seen, as we all have felt, that music may use science for its own benefit in the understanding and mastery of technique. By definite tests scientifically determined, it is possible to determine which children possess musical ability of a high order and may therefore be given the opportunity to become artists, and which possess it in less degree and should be given an opportunity to develop themselves along other musical lines. This is a difficult task, to be sure, because of the complexity of the factors which constitute ability in music, but, as this volume demonstrates, a task by no means impossible of accomplishment.

Fortunately for teachers of music, the author has constantly had a keen realization of the practical outcomes of investigations during all the years of his researches in the laboratory, and the editor is delighted to be able to include this volume in the Beverley Series.

AUTHOR'S PREFACE

This monograph is addressed to students of applied psychology. By content, it appeals directly to those who are interested in music; by method and treatment, it may serve as a somewhat intensive presentation of a specific subject for the student of educational psychology, child-study, vocational and industrial selection, or vocational and avocational guidance.

The scientific study of the artistic mind is a somewhat baffling undertaking. There are no substantial precedents; the available scientific data are extremely meager; by nature the artist himself is but little interested in the process of his mental dissection; and, after all, the varieties of artistic minds are legion. But the time is ripe for a vigorous application of the technique of psychological inventory to practical affairs, and the discovery and fostering of human talents is indeed both practical and practicable. The stress of war forced our army to adopt psychological methods for the selection and rating of the human energies of men for assignment to service and for promotion. When the best results are demanded in any occupation, haphazard procedure must give way to procedure on the basis of ascertained facts. When Music shall come to her own she will come to the musically gifted: to that end musical talent must be revealed and encouraged.

The system of evaluation of musical talents to be reviewed in this book will find a large field of usefulness in the ele-

mentary schools. A set of exercises is being worked out for the introduction of some of the most important tests in this series as a part of the regular instruction in certain grades of the elementary schools. This will secure a sort of "dragnet" survey of musical talents, as all the children in the community will be reached when they pass through these grades. It will stimulate an interest in the search for talent and efforts in the conservation of talent on the part of all concerned, particularly the teachers. Among the pupils it will cause a wholesome awakening to a recognition of their particular talents. For teachers of music it will stimulate the recognition of responsibility for the talented children of the community. It will be a part of the coming system of vocational and avocational advice, and should be a potent instrument in the development of community interest in music. The tests themselves constitute very profitable musical exercises.

If the great musicians can live before us in the wonderful reproduction of the modern phonograph, tone-producing instruments employed in the measurement of musical talent might equally well be made to perform for popular presentation through this medium. To test this assumption we made accurate measurements of the reliability of the reproduction in phonograph records and found that, for most purposes, such a record is as good as the original instruments and that in some respects the record has an advantage over the original instrument in that it makes it possible to standardize the test material with accuracy.

The first series entitled "Measures of Musical Talent" is started with five double disk records, each illustrating a basic test as follows: the sense of pitch (Chapter II), the sense of intensity (Chapter III), the sense of time (Chapter

IV), the sense of consonance (Chapter VII), and musical memory (Chapter XII). This series will be extended from time to time as progress is made. These records have been made by the Columbia Graphophone Company through whose agencies they may be obtained. They are inexpensive and permanent and may be played on any good phonograph.

With these records a booklet of instruction is furnished free, giving directions, norms, and interpretations, as they may be employed for class experiments in psychology; for musical surveys in the elementary schools; for the analysis of talent in the music studio, and for scientific entertainment in home circles.[1]

A second series embraces the motor tests. For this there are available instruments and methods for the measurement of timed action, rhythmic action, motility, singing in pitch, and other tests as outlined in Chapters IX and X. The use of these is more limited because the test can be made only upon one individual at a time; but their application is of broader significance inasmuch as they measure basic capacities for many occupations besides music.[2]

While there may seem to be much in the form of specific guidance in this volume, the effort has been made throughout simply to expose the facts in specific instances and indicate their possible bearings, leaving it at every stage to the reader to take larger situations into account and to feel the

[1] A monograph on "A Survey of Musical Talent in Public Schools" will appear at an early date as a research bulletin from the Iowa Child-Welfare Research Station (Iowa City, Iowa). Another monograph on the analysis of musical talents in the music studio and the music school will appear as Volume VIII of the University of Iowa Studies in Psychology (The Psychological Review Publishing Co., Princeton, N. J.).

[2] The principal instruments in these two chapters may be obtained from the C. H. Stoelting Co., Chicago, Ill.

responsibility for working out in his own experience the applications that the facts might warrant. This is particularly true of the public school survey in which the main object is to get the facts and then leave them as a standing challenge to parents and pupils.

This volume is primarily a collective and elementary presentation of the results of investigation by the author and his pupils and associates and must, therefore, go forth essentially as a communication from our laboratory, which is devoted largely to the study of the psychology of music. Limits of space preclude a more general and historical treatment.

The author is indebted to the *Musical Quarterly, Science, The Music Supervisors' Journal, The Proceedings* of the National Music Teachers' Association, *The 18th Year Book* of the National Society for the Study of Education, *The Musician,* and *The Étude,* for the privilege of using parts of material originally published in those journals. For generous equipment, research personnel, and a hearty encouragement of specialization within the field, the author acknowledges his profound obligations to the State University of Iowa. The author also acknowledges the favor of The Macmillan Company for use of the illustrations from "The Science of Musical Sounds" by Dayton Clarence Miller and from "Experimental Psychology" by Edward B. Titchener. Owing to the newness of the venture, advice has been sought and received from a host of friends. To all of these and to the laboratory students in the psychology of music who have shared the joy of comradeship in research, — a lasting gratitude.

C. E. Seashore.

Iowa City, Iowa.
September, 1919.

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The Great Force

"I am the soul of the joy of life — the companion of its sorrows.

"All moods are mine. I am hilarious. I am frivolous, I am gay, I am serious. I am sad. I spin out the silver thread of happiness, the golden thread of comfort and solace. On wings of melody I bear the dreamer off to strange places and strange lands. To the wanderer I sing of home. In the despondent I renew resolve. To the despairing I bring hope. In the child I engender pure tastes, refinement, and inspire noble thoughts and high ambitions.

"I am ever ready. I never tire. I am a well-spring of inspiration, relaxation, recreation. I am at home in the dwelling of the richest or the most lowly in the land — where religion reigns or under the roofs that know not God.

"In peace I had ever been at the service of man. In war was I to be found wanting? Was I to be thoughtlessly brushed aside in the tremendous rush to arms? Many there were who would have stilled my voice till peace should come again. But I was put to the test. I was not found wanting. I proved my worth. I found my niche, for I am full of cheer, of undying, unflickering resolve — of the spirit that knows not defeat.

"Day and night found me on duty with the saviors of civilization — in the camps, on the ships, in strange foreign villages, in dugouts, in trenches right up to hell's partition — everywhere where death and danger were commonplace, soothing tensed nerves straining at the leash, singing of victory amid the battle's roar, — restoring the balance of upset minds — chanting the dirge of deviltry.

"In war, as in peace, food, clothing, and shelter come first in sustaining morale and rendering comfort. I come next.

"I helped to win the war.

"I am MUSIC."

— Courtesy of *Life.*

THE PSYCHOLOGY OF MUSICAL TALENT

CHAPTER I

THE PSYCHOLOGY OF THE MUSICAL MIND

I. The Point of View

Three branches of the psychology of music. Three aspects of the psychology of music are fairly distinct: the psychology of musical talent, the psychology of art principles involved in music, and the psychology of musical training. The present volume is restricted to the presentation of the first of these three aspects — the psychology of musical talent, an account of the musical mind.

Aim, to describe and explain. This subject is treated both from the theoretical and the practical point of view, the aim being to describe and explain the musical mind in such a way as to serve in the recognition, the analysis, the rating, and the guidance of musical talent.

What constitutes description and explanation in psychology. Description and explanation of this sort involve in general for each mental process analysis of the process into its structural elements, classification, identification of purpose, tracing genetic history and physiological conditions, and statement of laws of behavior. Thus, a psychological account of musical rhythm begins with an analysis of this experience into its component psychological elements.

These are then classified and the significance of each is discovered by tracing the purpose it serves in mental economy, its evolution in the race, its development in the individual, and its physical and physiological bases. Beyond such descriptive account the more exact knowledge may then be stated in terms of laws of behavior.

Value of the psychology of music. From an adequate study of types of mind of this sort, we should gain a systematic knowledge of the mental life involved, and the ability to interpret this life for the enlargement of our horizon in culture and for the acquisition of power in efficiency. It should lead to an appreciation of mental life for itself, and should lay a foundation for the understanding of ourselves and our pupils as musicians, our art, our methods of procedure in musical training, and the conservation and direction of artistic talent.

The experimental method. Our approach is that of experimental study. Where there is no experiment there can be no science. Psychology is scientific just to the extent that it is based upon principles of experiment and is faithful to them. In the study of a given mental process, the experimental method demands that the process shall be specifically identified and reasonably isolated for description; that it shall be under control so that it can be kept constant, can be repeated, and can be varied in one aspect at a time; and that the results of the observation shall be recordable and verifiable. In so new a science as psychology, and particularly in the almost unexplored field of the psychology of music, such principles can be complied with only in part; but adherence to them fosters a critical attitude and chastens the treatment of those phases which have not yet been brought under experimental control. We shall,

therefore, not vaunt the slogan of science, but shall modestly try to maintain, in spirit, the scientific point of view.

The relation of applied to theoretical psychology. To be sound, applied psychology must involve and rest upon theoretical psychology; but the theoretical remains incidental, serving merely as a groundwork to the applied. In music the way of applied psychology is still desperately obstructed by the underbrush of primitive views of mind and the barbed-wire entanglements of the warfare of uncritical theories and self-interests. We can at best pave or point the wise way only in part; the most effective guidance comes from knowledge of the situation rather than from directions or rules of procedure. Therefore, the mere description of aspects of the musical mind will often be placed in the foreground, without effort to point the moral, particularly when the morals are countless.

Scientific vocational guidance. At the present stage a scientific vocational guidance in music must be admitted to be a vision rather than an avowed aim. Yet in no other field does vocational guidance give so great promise of becoming scientific as in music. Among the reasons are these: music requires specific talents; these talents can be identified and rated by psychological methods; to a certain extent they are essential to happiness and success in the art; musical education is expensive; misguided talent may entail a chain of grievous misfortunes; and, other things being equal, musical advantages should be conferred in proportion to the degree of talent.

Avocational guidance in music. But the pursuit of music as a vocation is limited to a very small number of those who legitimately pursue music as an art. Avocational guidance in music, therefore, becomes more important

than vocational guidance; for avocational guidance is the systematic direction of children and youth in the selection and organization of their avocational pursuits — those pursuits which we follow, not as occupations but as diversions and merely cultural quests. The goal of vocational guidance is efficiency in the profession — a sort of business. The goal of avocational guidance is self-realization in the enjoyment and expression of the beautiful. There is no contradiction between these two, and they have many things in common, but the pursuit of art for itself is the larger aim.

The conservation of artistic energies. From this point of view the applied psychology of music leads to a conservation movement. Indeed, it is not out of place to speak of the saving of life by the discovery and encouragement of unknown genuine talent in such a way as to lead to achievement in the art. Surveys of public schools show clearly that very little correlation exists between the possession of musical talent and the selection of children for musical education; and records of the extent of children's musical education show no close relationship to the possession of talent. Thus, in recognizing the possibilities and worth of genuine talent and the futility of trying to make a precious metal out of a base one, musical guidance may be looked upon as alleviating human suffering, both of the prospective musician and of those associated with him. It should certainly enhance artistic life, both in the individual and in the community.

A pattern for scientific guidance in other fields. In so far as psychology of musical talent is a scientific basis for vocational guidance in a specific field, it may serve as an exemplification of principles which may be extended into

other fields. The psychology of talent in the graphic and plastic arts and the psychology of talent in dramatic art suggest themselves. But even in the study of fitness for occupations in the trades and industries we shall find many analogies.

Based upon measurement. The applied psychology of music in the interest of guidance rests upon mental measurements. We now find it quite feasible to measure certain musical talents quantitatively. Since this feature is comparatively new, it will be necessary to give considerable space to the description of methods and means of measurement, not only in order to show how it may be done, but primarily because that is the best way of isolating and describing a mental process. Not all talents lend themselves to measurement. Specific and simple talents, such as the sense of pitch or the sense of time, can be measured with precision. In general, the more complex and diffuse a talent is the less it lends itself to direct measurement. Musical reflection and musical emotion are examples of talents which are too diffuse to be measured as such, although we can weigh many of the factors which are determining components.

The experimental attitude. Measurement is a form of experiment. Therefore, as in experiment in general, the conception of measurement is helpful in the evaluation of many factors which we shall not undertake to measure. It furnishes a point of view which results in a penetrating insight, a power of analysis, a critical reserve, and accuracy. Where we cannot measure directly, we can often evaluate indirectly; for example, when an observer has several hundred records of his rating of voice registers he can gradually rank these in the order of excellence and in that way establish a fair scale for the rating of particular voices.

Hierarchies of talents. Musical talent is not a single talent; it is a hierarchy of talents, many of which are entirely independent of one another. Therefore, the description of a musical mind reduces itself to the picturing of the relative prominence or latency of each musical talent. The talents naturally group themselves so that we have, for example, the tonal group, the rhythmic group, the motor group, the intellectual group, and others; and within each of these we may trace much detail.

Musical talent an inborn gift. Musical talent is a gift bestowed very unequally upon individuals. Not only is the gift of music itself inborn, but it is inborn in specific types. These types can be detected early in life, before time for beginning serious musical education. This fact presents an opportunity and places a great responsibility for the systematic inventory of the presence or absence of musical talent.

The musical mind a normal mind. The musical mind is first of all a normal mind. Indeed, the normal mind is musical to the extent that it is normal. It will be out of the question to attempt a general account of the mind as a whole. We must take it for granted that the musical mind is an aspect of a normal personality with endowments for a general mental life, and we must also take the general psychology of such mental life for granted. We shall not, therefore, describe the musician as a whole but only with respect to those aspects of talent which are peculiarly necessary for music.

II. An Inventory

Twofold basis of classification. In making an inventory of the musical mind, we are guided by two coördinate

bases of classification: first, the attributes of sound; and, second, the generally recognized powers of the human mind.

The four attributes of sounds. Sounds have four attributes: pitch, intensity, duration, and extensity. In terms of these four attributes, we can account for every possible shade of difference in sounds — from the most exquisite nuances of the human voice, through all the range of instrumental tones and the sounds of animate and inanimate nature down to the inchoate noises.

Principles of the classification. Our classification of items will, therefore, be a list of those traits of the human mind which are necessary for the apprehension and expression of the recognized attributes of sound. These are the hearing of tones, the production of tones, the representation of tones in memory and imagination, musical thought, and musical feeling.

Factors of the musical mind.

I. Musical sensitivity
  A. Simple forms of impression
    1. Sense of pitch
    2. Sense of intensity
    3. Sense of time
    4. Sense of extensity
  B. Complex forms of appreciation
    1. Sense of rhythm
    2. Sense of timbre
    3. Sense of consonance
    4. Sense of volume

II. Musical action
    Natural capacity for skill in accurate and musically expressive production of tones (vocal, instrumental, or both) in:

1. Control of pitch
2. Control of intensity
3. Control of time
4. Control of rhythm
5. Control of timbre
6. Control of volume

III. Musical memory and imagination
1. Auditory imagery
2. Motor imagery
3. Creative imagination
4. Memory span
5. Learning power

IV. Musical intellect
1. Musical free association
2. Musical power of reflection
3. General intelligence

V. Musical feeling
1. Musical taste
2. Emotional reaction to music
3. Emotional self-expression in music

The sense of pitch. The sense of pitch is involved, not only in the hearing of melody and harmony, but also in the hearing of tone character in many complex forms. Pitch is the raw material of music. The function of the higher capacities, such as memory, imagination, and feeling, or playing and singing, is limited by the degree of sensitiveness to pitch. This becomes significant when we find, for example, that, according to actual measurement, one person may be two hundred times as sensitive to pitch as another of equal age, social standing, and general intelligence.

The sense of intensity. Then, we have the sense of intensity, which represents the capacity for appreciation of differences in strength of sound. This is basic for the hearing

of musical expression and the appreciation of touch, and for modulation in intensity or loudness and volume.

The sense of time. The third elemental capacity is the sense of time. This is basic for all perception of rhythm and for rhythmic action. A limitation in this capacity for hearing time sets a corresponding limitation upon feeling, thought, and action.

The sense of extensity. The sense of extensity furnishes the immediate experience of the magnitude or space relations of sound, particularly volume. Since it is a counterpart of pitch, which it parallels, it holds but a secondary place in the psychology of musical talent.

Simple, immediate, and elementary forms of all auditory impressions. Such are the four fundamental capacities of hearing. They vary quite independently — pitch without time, time without pitch, intensity without pitch, extensity without intensity. Since these are the four channels through which all sounds must enter, all that is within the mind is characterized by their receptivity or non-receptivity.

Complex, derived, and richer forms of all auditory impressions. There is another screen inside this outer screen of the primary capacities, representing the ability to receive auditory impressions; in this we find four principal phases, namely, the sense of rhythm, the sense of timbre, the sense of consonance, and the sense of volume.

The sense of rhythm. The sense of rhythm rests upon the sense of time, the sense of intensity, and mental imagery, but it requires in addition a number of affective and motor qualifications; thus a person may have a keen sense of time and intensity and still not have a pronounced sense of rhythm.

The sense of timbre. The sense of timbre is essentially the ability to hear the tone quality, tone character, or tone color of sounds. Timbre is essentially a pitch complex. It rests primarily upon the sense of pitch and in a secondary way upon the sense of intensity; but it requires something additional not embodied in either of these separately; a person may have a keen sense of pitch and a keen sense of intensity and yet not be keen in the sense of timbre.

The sense of consonance. The sense of consonance is the simplest form of musical hearing which underlies the combination of tones, either simultaneous or successive, as in melody or harmony. This rests primarily upon a sense of pitch, but involves higher elements so that a person may have a keen sense of pitch and yet not be effective in the sense of consonance.

The sense of volume. Volume in music may be analyzed into its component elements: extensity, intensity, timbre, and the number of sounds. The appreciation of volume may, therefore, take several forms and the volume may be of different kinds.

Capacities for action parallel to capacities for hearing. Turning from musical hearing to musical action, we demand the capacities for producing pitch, time, and intensity, and their derivatives, rhythm, timbre, and consonance, by voice and by various kinds of instruments.

Pitch, intensity, time. The ability to sing in pitch, the possession of a large and suitable pitch range of the voice, the ability to play in pitch on instruments whose pitch is wholly or partly controlled by the player, present quite different claims upon the human organism. But each can be isolated for examination and rating. The control of intensity, which we ordinarily call touch, whether it be vocal or

instrumental, reduces itself largely to a fine general muscular control. The ability to keep time, both vocally and instrumentally, also rests upon a peculiar gift of precision in action. These three capacities are comparatively simple and specific.

Control of rhythm. When we turn to rhythmic action, the situation is different. Here we deal with the responsiveness of the whole organism, with certain unconscious and instinctive reverberations, and a rich play of emotional expression in action. Likewise, the control of timbre as tone quality demands a very delicately adjusted system of motor control. In the voice, for example, this calls for favorable vibrating, resonating, and energizing organs, and a delicate control of these by a musical mind.

Control of timbre. On the other hand, the tone quality of the stringed and other instruments, in which the tone quality depends largely upon the action of the player, is conditioned upon general motor control as the servant of a refined and analytic hearing. Likewise, the instrumental rendering of tones in pitch, sequence, or concordance, as in melody and harmony, demands, on the motor side, a good general motor control as the organ of musical intellect and feeling.

Musical imagery. But the hearing of tones and the producing of tones does not make music. One of the most essential groups of capacities is that which we may call representation, including memory and imagination. The ability to re-live music realistically in memory and imagination depends upon the power of auditory imagery and motor imagery, and is very much enriched by the possession of imagery through each and all of the senses. A rich imagery will enable one to recall or invent and review mentally

with detailed accuracy in hearing, and with the accompanying motor and emotional effects.

Musical imagination. But one may have a rich imagery without power of imagination; and music is a creation of imagination, not only in composition but as re-creation in playing or singing as well as in listening.

Musical memory. The need of a musical memory is self-evident. It is not merely a matter of recalling selections. Memory enters intricately into all stages of hearing, feeling, and rendering of music. The learning process is one special aspect of memory. Each individual has a certain personal equation for capacity in rate and excellence of learning, and each of us has some apt preference for one kind of material or another. For a given activity, such as singing, sight reading, piano exercises, this may be expressed in the form of what is technically called a learning curve.

Musical thought. The musician must also be a certain kind of thinker. A thinker in any field may be judged on three essential scores: namely, his ideas in stock, his power of reflection, and his general intelligence.

Musical feeling. Last, but not least, the very heart of music is feeling, for without musical feeling music is soulless. Although feeling is in one sense a highly specialized capacity, it involves the reaction of the organism as a whole in its play with time, tone, and intensity of sounds. In general we may sample the prevailing type of capacity for feeling by three fundamental aspects: musical taste, which is the naïve and immediate natural response to certain kinds of musical situations; emotional expressiveness; and the ability to convey emotional effects to others through the art of music.

The inventory of capacities a classification for the science

of the musical mind. Such in brief is the barest skeletal outline of a musical mind. It will now serve as a basis for the classification of our problems and should assist the reader in maintaining his orientation throughout the details in the following chapters. Indeed, this inventory becomes the topical outline of the science of the musical mind.

Mind not a series of compartments. In judging such an inventory of the musical mind, we must be warned against the notion that the human mind is made up of faculties, independent compartments, as it were, which together form a sort of filing case, storehouse, or source of information within which the contents may be shuffled. Some forms of this theory prevailed in psychology a hundred years ago; and a very superficial and absolutely absurd offshoot of that theory is the doctrine and practice of phrenology.

Mind a unit as a whole. The fault of the "faculty psychology" was that, while the various mental aspects were more or less appropriately described, it failed to recognize the inherent unity and the intricate interweaving of mental powers. We say now there can be no thought without feeling and action; there can be no action without feeling and thought; there can be no feeling without thought and action. So there can be no hearing without imagination and action; there can be no feeling without instinct and memory. These illustrations suffice to emphasize the fact that there are no isolated faculties in operation in the human mind; the mind is always in operation as a whole.

Use of terms like capacity, ability, trait, and talent. Yet, we may speak of well-recognized divisions in the human mind in a very serviceable sense. By these divisions we mean the dominant traits. When a lover of flowers looks

at a rose and enjoys its sweet odor, he is exercising several powers of the human mind — the perception of color, the perception of odor, the action of holding with the hand, and the feeling of agreeableness. It may well be said that, in the moment of enjoying the rose, his whole mental organism is involved directly or indirectly. But it is possible to shift the point of emphasis from the perception of color, or the perception of odor, or the perception of touch, or of temperature. The imagination or memory of each of these and other qualities, the concepts of beautiful roses unlimited in number, judgments and reasoning about the value and methods of producing roses, the intellectual sentiment, the organic feeling of well-being, the emotional expression of satisfaction about roses, the habit of holding with the tips of the fingers, the instinct to draw near to the nostrils, the automatic tendency to lean toward a beautiful object, the deliberation and decision to assure oneself of the possession of roses in the future, or to express a sentiment through the gift of this particular rose — in all these, the human mind was involved as a whole and yet there were dominant traits of the mind recognized in each situation. The achievement of the mind in each of these aspects was limited by the capacity in these various main channels of expression. Therefore, when, for our present purpose, we analyze the musical mind into its component factors, it is done in this spirit of pointing out the dominant phases in which the musical mind receives impressions, re-presents and elaborates them, and responds in feeling and action.

Capacity, ability, sense. Modern psychology distinguishes between capacity and ability. The term "capacity" has reference to the inborn or native power; the term

"ability" is used to designate acquired skill in the use of a capacity. Thus, each of us has a certain native capacity for memory, but we develop various kinds and degrees of ability in the use of this capacity. The term "sense" is here used freely to designate natural fitness in a given sensory capacity.

The personal equation. The permanent traits of an individual, as conceived in terms of capacities, are sometimes spoken of as his personal equation. One person is slow and sure; another is quick and sure; one lives in the world of feeling, another in the world of reflection; one has a remarkable sense of rhythm; another is devoid of this capacity. The knowledge of such traits or capacities can be built up into a personal equation which will enable us to predict with reasonable certainty the aptitude and probable promise of achievement of such a person.

III. Records of Talents

Concrete examples. In order to bring more clearly before our minds the aim and achievement of this type of psychology of music, it may be profitable at this stage to present a few actual cases of records from the laboratory file. The measurements herein used will, of course, be explained later in their respective places. Most of the names of the measurements are, however, self-explanatory to some degree. All that is aimed at here is to present a bird's-eye view of the goal toward which we are working.

Unit of measurement: percentile rank. All records of measurements are kept in terms of percentile rank, a sort of universal method of representing the results of very different kinds of measurements in common and comparable terms. If we have the records of any measurement of a

thousand persons or more, we may arrange those records in the order of excellence for the purpose of making a measuring scale. If the group has been fairly selected so as to be representative, we may divide it into a hundred units, the lowest unit being 1 and the highest 100. All the intervening cases are arranged in the order of excellence between these extremes, the average being 50. Since the scale is arranged in the order of rank on the basis of 100, we call it percentile rank. It forms a simple way of judging ourselves in comparison with others. That is, it enables a person to say quantitatively that his ability is, for example, average (50 per cent), is 7 per cent from the bottom, is 7 per cent from the top, or any other rank indicated. One may even visualize himself as standing near the head or at the foot of a line, as the case may be. This simple terminology relieves parent, pupil, and teacher from the necessity of thinking in terms of technical and complicated measurements, such as terms of vibrations, seconds, or units of energy. From such a scale we construct a conversion table for each and every test, such that it will show directly the equivalent of any record in that test in terms of percentile rank. Obviously one must bear in mind that the differences among individuals are larger near the extreme than in the middle region. The step 98–99 per cent is larger than the step 49–50 per cent.

Talent charts. In assembling the records for final report, it is convenient to represent them in charts, as shown in the accompanying figures, in which the name of the measurement is given on the left and the percentile rank at the top. A chart or graph of this kind enables one who is familiar with the terminology to see in relief the contour and relationship of the different talents recorded for an individual.

The features of talent are seen at a glance just as one sees the features of the face in a photograph.

Supplementary information. To supplement the records of quantitative measures we ordinarily collect information from the person examined, as, for example, in the following questionnaire :

I. Musical training
  1. In early expression of musical interest
  2. In elementary schools
  3. Through private lessons
  4. Through musical environment in the home, through opportunities for hearing music, good or bad

II. Musical expression
  1. Hours per week (average for last five years) spent in (1) singing, (2) playing, (3) hearing music
  2. The most difficult musical selections you can render reasonably well alone or with others
  3. Public performances or participation in music

III. Musical appreciation
  1. The kinds of music and the elements of music that appeal to you
  2. The kinds of music and the elements of music that bore you or give you displeasure
  3. Degree and kind of feelings and emotional expressions that music arouses
  4. Characteristic rôle of music in your daily thought
  5. Devices that you have employed for gaining or avoiding musical environment

This is further supplemented by notes, observations, or reports on any mental, physical, or environmental factors which may be relevant.

Advantage of the scientific examiner in music. The psychological examiner in dealing with pupils individually has at his command the information and means of judging

ordinarily possessed by the music teacher, but he has in addition his psychological measures and his psychological technique of observation and description.

Two examples of the psychological description of musical talents. The first two cases which may serve as illustrations are two little ten-year-old girls who are classmates and playmates. Let us call the first one Theodora and the second one Rosabelle.

Theodora. Theodora has a decidedly musical mind. In the three basic capacities for musical hearing — the sense of pitch, the sense of intensity, and the sense of time — she is superior and well balanced. Her sense of consonance is of a high order. Her acuity of hearing is only average, but this condition is not of the type which will affect music seriously in view of her superior sense of intensity. Her imagery is all of the moderate type. Her auditory imagery can be developed as an excellent support to her superior sensory powers and the motor and visual imagery are prominent enough for an emotional background in music. Her lowest record is on motility, which is characteristic of the fact that she has a deliberate type of mind and is steady in her movements. Her physique is average, as indicated by her grip and ergogram. Her precision of movement and her simple response to a simple signal are slightly above average; while her simple response to a complex signal is decidedly better. Her capacity for serial association of sound and action is good; whereas her association for visual impressions and action is barely above average. Her timed action and her rhythmic action are both good. Her general motor reliability is superior. She sings in key with remarkable ability and reproduces the interval with superior precision, although her voice control is only moderately

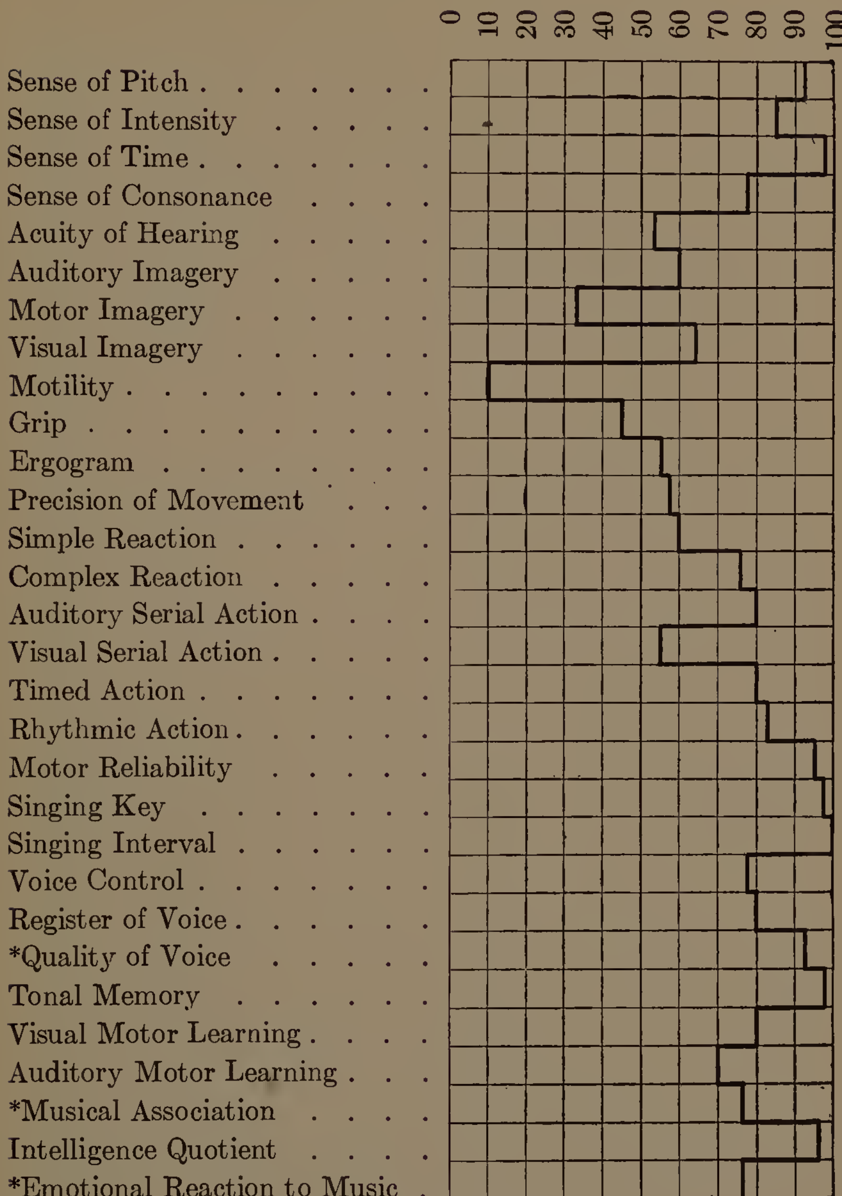


Fig. 1. — Talent Chart of Theodora.[1]

[1] The items marked with an asterisk in the charts represent mere estimates in the absence of norms.

good for nuances of pitch. She has a good voice register and an excellent voice quality. Her tonal memory is decidedly superior. She gives superior promise for speed and reliability in the acquisition of skill in music. Her associations are highly versatile and remarkably well balanced, but not peculiarly musical. Her mental age is fully two years in advance of the normal. Emotionally, she is cool and undemonstrative, but capable of deep feeling for music.

Generalizing from the above, we observe that Theodora has a rare balance of high sensory capacities for music, that she is of the strongly intellectual rather than of the motor type of mind, and that, therefore, she is not so skillful in performance as she is in hearing, appreciation, and intellectual control. Her motor responses are of the slow, deliberate, and reliable type.

Theodora belongs to a decidedly musical family and is given excellent musical advantages. On account of her remarkable versatility in other respects, she approaches music, like other interests, in a matter-of-fact attitude.

Rosabelle. Rosabelle is not of the musical type of mind. She has an average sense of pitch and an inferior sense of intensity, but a rather good sense of time. She possesses but a slight sense of consonance. Her acuity of hearing is below the average. She has but little auditory imagery, but her motor imagery is pronounced and her visual imagery average. She has good general motility. Her physique is slightly above average. In precise movements and in simple reaction she is about average, but her complex reaction is superior. Her auditory serial action is below average, while her visual serial action is very good. She is decidedly inferior in timed action and poor in rhythmic

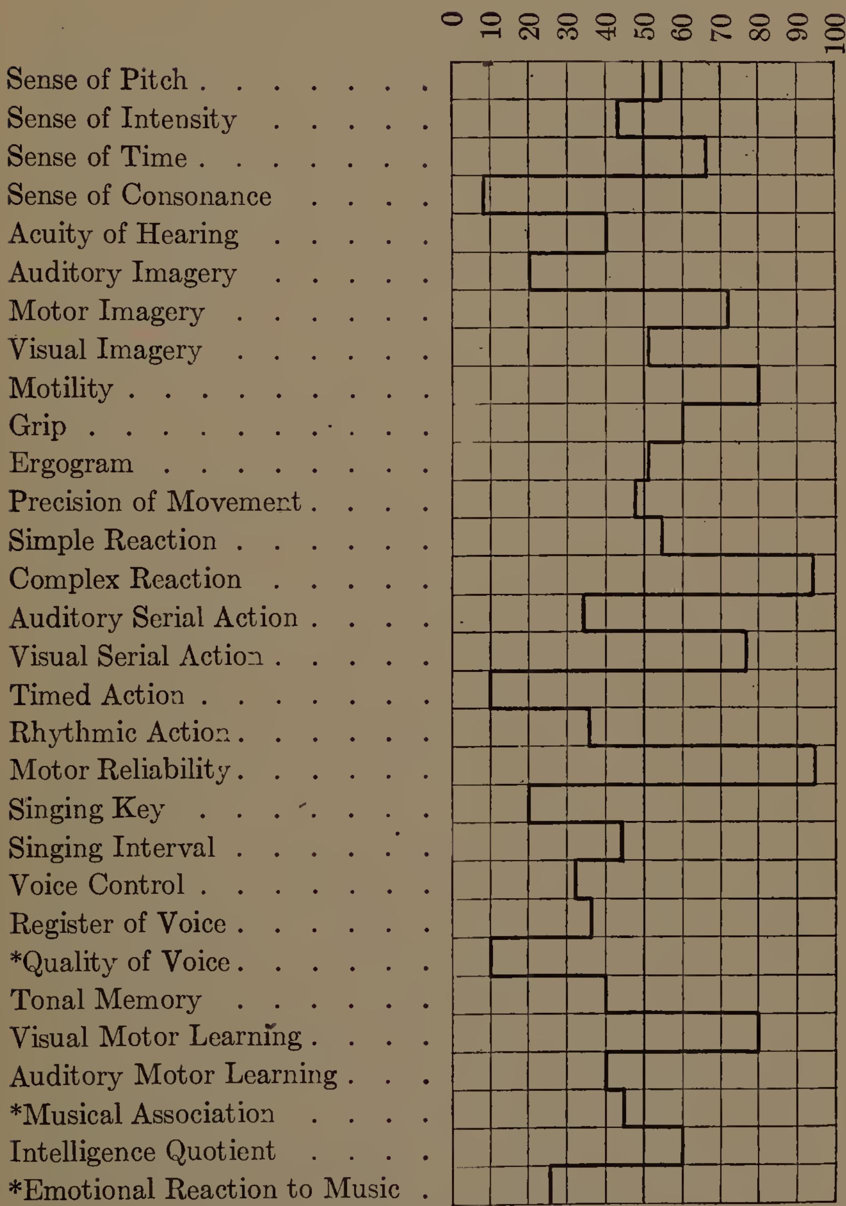


Fig. 2. — Talent Chart of Rosabelle.

action. In general motor reliability she is superior. Her capacity for striking the pitch of a note is inferior although she sings the common intervals with a moderate accuracy and her voice control of pitch is fair. She has a fair register of voice, but the quality is inferior. Her memory for tones is not quite up to the average. Although she has very good capacity for visual-motor learning, her auditory-motor learning curve is below average. Her musical associations are superficial, although she has a fertile mind and her mental age is above normal. Although otherwise quite emotional, she is but slightly moved by music.

Summarizing the characterization, we find that Rosabelle is of the intellectual-motor type, normally emotional. She is but slightly ear-minded and does not live in a tonal world or respond effectively to musical sounds and associations.

Rosabelle takes a superficial interest in music and associates with musical children but her musical reactions are scarcely emotional or artistic.

Comparison of three grades of talent. The next three cases are taken from a collection of three hundred and eight records of this type on university students. The first represents a decidedly musical type of mind, the second, a decidedly unmusical, and the third, what is commonly called an average musical mind. All have had musical advantages. Let us call them Mr. White, Mr. Black, and Mr. Gray, respectively.

Mr. White. Mr. White's sense of pitch is superior; his sense of intensity is good; his sense of time is excellent. His sense of consonance is superior. His acuity of hearing is also superior. He has good tonal imagery and superior tonal memory. His general motility, timed action, and

rhythmic action are quite good. He has superior capacity for singing in pitch, sings intervals well, and has good voice control for pitch. He has a superior register and good quality of voice.

In general, Mr. White has an unusually strong and well-balanced musical mind, ranking in this respect within the best three per cent in a normal community. He has always

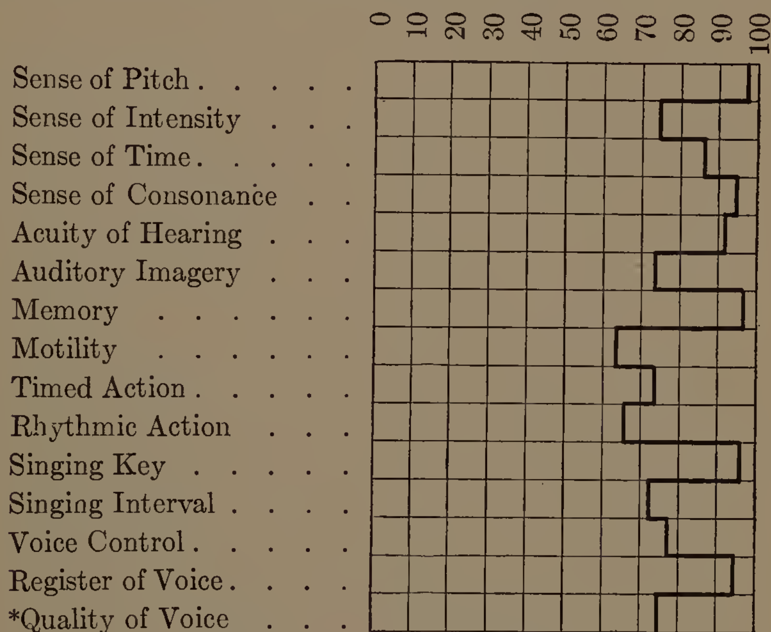


Fig. 3. — Talent Chart of Mr. White.

manifested great interest and activity in music, but has had only a small amount of formal training. He lives in a tonal world and is emotionally responsive to music.

Mr. Black. Mr. Black is decidedly inferior in all the basic capacities for music. The three capacities in which he ranks best — general motility, acuity of hearing, and timed action — are therefore of scant musical significance. So far as musical resources are concerned, his record is remarkable for its uniform inferiority. He has taken music

lessons but has met with failure. He shows only a perfunctory interest in music. This record removes all necessity for uncertainty and pretense.

Mr. Gray. Mr. Gray has a fairly good sense of pitch, very poor sense of intensity, and poor sense of time. His sense of consonance is below average. His acuity of hearing is exceedingly fine. He has good tonal imagery, but decidedly inferior tonal memory. His general motility is superior and his timed action is good, but his rhythmic action is poor. He sings in fairly true pitch and reproduces intervals fairly well. He has a very wide register of voice but poor quality. In general, Mr. Gray is a fair type of what is popularly called "average" musical ability, that is, he ranks high in some talents and low in others.[1] He has had little musical education, but possesses a decidedly artistic type of mind and lives much in musical feeling and vital artistic appreciation.

Two talented schoolgirls. The next two cases are taken from a collection of twenty-five hundred records of this kind on school children in school surveys, and are among the best that we have found. They are girls twelve years old. Let us call them Viola and Jean, respectively. These records were made in school during school hours and the experimenter did not know any of the children personally. It is, therefore, interesting to find that, when report to the school authorities was made and these girls were pointed out as exceptionally fine, Viola proved to be a girl who had enjoyed most excellent musical advantages, came from one of the best families of the city, and was scheduled for a public recital for the following Sunday afternoon.

[1] While this well represents the common type, in its difference in the talents, it also exposes the fallacy of calling such diversity "average."

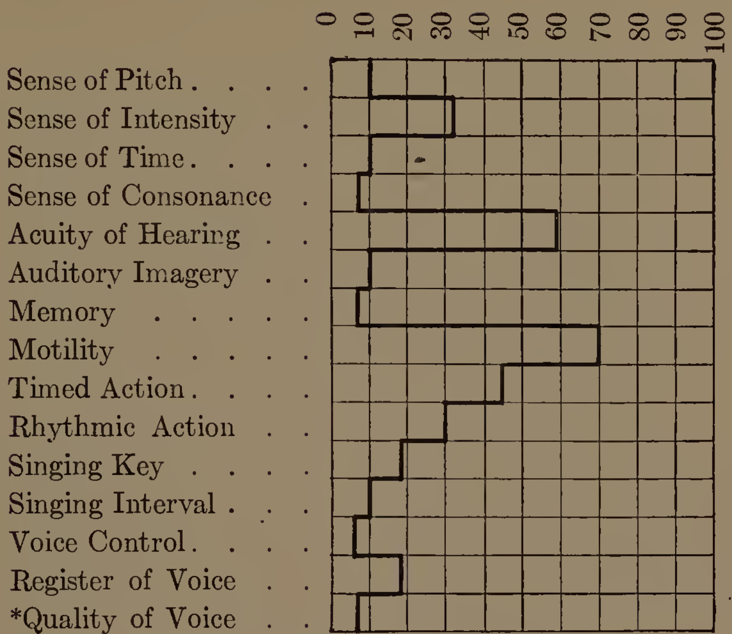


Fig. 4. — Talent Chart of Mr. Black.

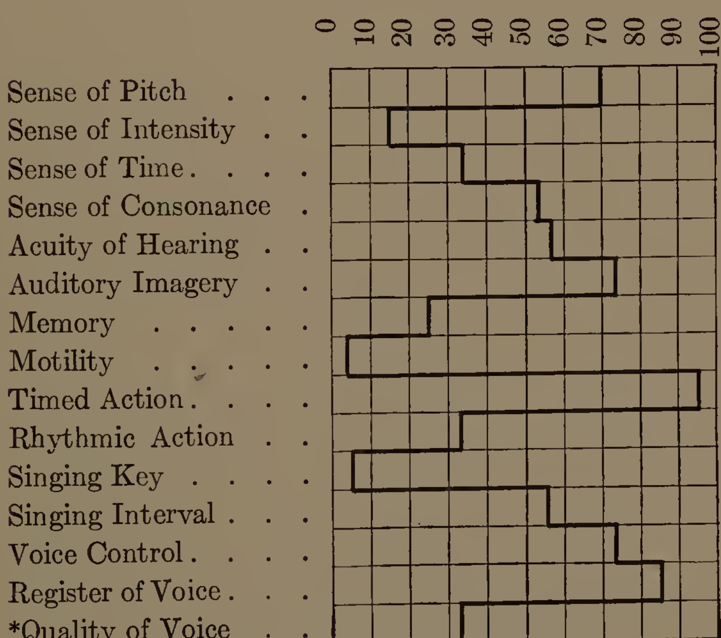


Fig. 5. — Talent Chart of Mr. Gray.

The musically unknown and uneducated. When Jean was picked out as having the best record found in her grade in the survey of her town, it was discovered that she was

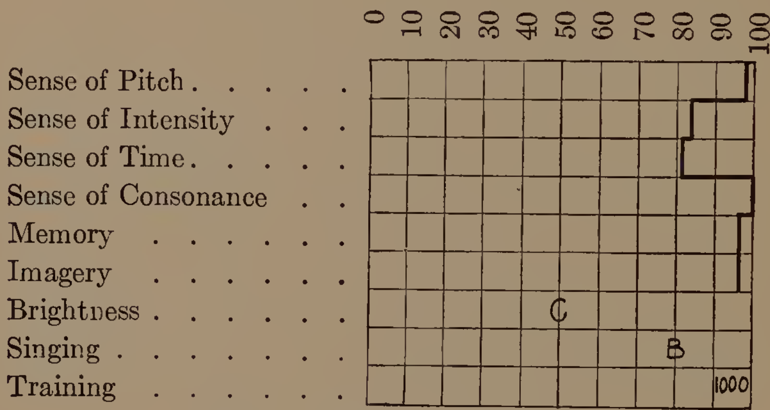


Fig. 6. — Talent Chart of Viola.

the daughter of very poor parents, had enjoyed no musical advantages, and, indeed, had been irregular in much of her school work on account of her poverty.

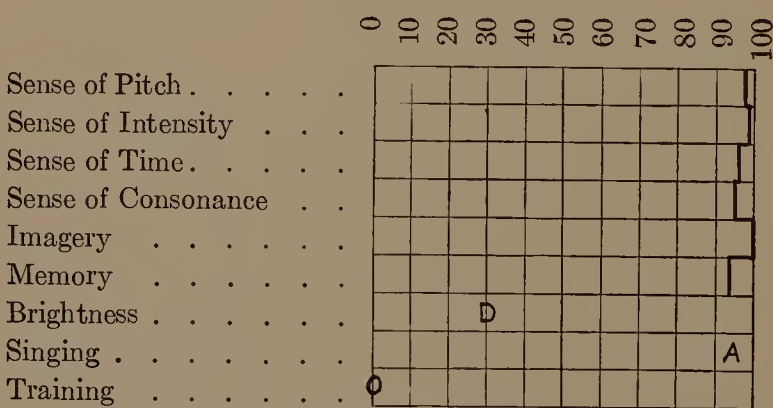


Fig. 7. — Talent Chart of Jean.

Brightness, training, and singing. According to the teachers' estimate, Viola was rated as average in general brightness (C), and Jean was rated as decidedly below average (D). The teachers also rated Viola's ability in singing

as very good (B) and Jean's as superior (A). The musical training is expressed in terms of number of hours of private lessons.

IV. The Value of a Talent Inventory

Known and unknown talent. Consider the last two cases and their meaning to parents and teachers. Viola, who has already found herself in music, took deep satisfaction in having this objective and impartial evidence of her superior promise for future achievement. Her parents were encouraged to spare no effort in her musical education and her teachers delighted to have this quantitative record of the rare qualities of her musical mind. From every point of view it was cheering and reassuring, although her ability had already been demonstrated in achievement.

Jean, on the other hand, was clearly a discovery. While the teachers reported, after she had been found, that she had been singing unusually well in school, no one had paid any attention to her as a musically talented girl. The report went not only to her parents, but, through the superintendent, to a woman's club which expressed its willingness to guarantee that Jean should have the opportunity of trying herself in a musical education. Although not notably bright, her organism is so decidedly musical that she is likely to distinguish herself, if given the right opportunities. It is no sacrifice for a music teacher to foster a charity pupil of that caliber.

Value of the search for and identification of talent. When surveys of this kind are made a part of the regular work in music in the fifth grade of the public schools, as is recommended, we shall have a sort of universal "dragnet" for the preliminary discovery of rare talent which would otherwise

be wasted. For the youth who contemplates a serious musical career, a thorough inventory may be of untold value in furnishing a quantitative indication of the probable prospect of achievement in music.

Value to music pupils. The music teacher may or may not be interested in making actual tests of talent a condition for admission to the conservatory, but, when once the pupil has entered, there can be no debate as to the desirability of a quantitative analysis and rating of talents for the purpose of determining the type of musical education for which the pupil is best fitted.

Value to teachers and patrons: diagnosis of difficulties. These tests also serve a sort of clinical purpose in that persons who have entered seriously upon a musical education and have struck difficulties may have the situation analyzed and diagnosed so that the exact nature of the difficulty may be known, and the teacher may proceed with knowledge, not only as to what the difficulty is but also as to whether or not it can be remedied.

Development of a scientific attitude. Studies of this kind must inevitably lead to the development of a scientific concept of the musical mind and therefore to a science of musical talent. They should lead to concrete and accurate observation and terminology of the musical life. It is not unreasonable to suppose that, as the result of an insight into the nature of the musical mind, there should gradually be built upon this a sound theory and art of musical education.

The psychological attitude. The author has elsewhere [1] pointed out that, after all, psychology itself will be the chief gainer. One cannot observe under controlled condi-

[1] "Psychology in Daily Life," Appletons, N. Y., 1913.

tions in a field so rich and unworked without gathering new facts, correcting errors, broadening views, and deepening insight into the nature of the mental processes in music.

In giving and taking advice of this sort we must not forget the enormous resourcefulness of the human will, and the possession of latent powers. A one-legged man may become a rope dancer, a blind man a guide, a man with wretched voice an orator. Furthermore, art is possible only where there is willingness to overlook faults. A singer may be permanently lacking in some fundamental capacity and yet have such merits in other respects, or have such exceptional ability in covering faults, that he may be successful in spite of an overt handicap. But even then psychology has warned and explained.

CHAPTER II

THE SENSE OF PITCH

I. Introduction

Nature of pitch. Pitch is the essential medium of musical appreciation and expression. The experience of tone is the experience of pitch. This experience of pitch may come to us in varying force, duration, purity, complexity, combination, and meaning; it may break forth in endless varieties of memory, imagination, thought, feeling, and action; but all these have reference to the basic experience of tone — pitch. As color is to the color artist, so is pitch to the musician; it is his medium of expression. Be it ideas or ideals, moods or passions, technique or sentiment; be it real sounds or imaginary; be it appreciation, execution, or composition; the essence, content, or plastic medium of music is pitch.

Limits of this chapter. Pitch is involved, directly or indirectly, in each and all the talents enumerated in the preceding chapter. The present chapter will be limited to a study of the hearing of pitch, as such. From the point of view of the psychology of the musician, as distinguished from the psychology of music, this becomes a study of the sense of pitch.

The present chapter will be comparatively long, not only on account of the relative magnitude of the subject, but

also because it will be convenient to discuss in detail methods of procedure and facts of general significance which are equally germane to the subjects in following chapters, but which may be stated once for all in this first context.

Principal topics. To study the nature of this capacity, its variability, and musical significance, it will be necessary for us to consider briefly the physical and physiological basis of tonal hearing and then to examine in detail its chief psychological aspects, such as tonal limits, methods of measuring pitch discrimination, individual differences, variation with age, sex, training, and intelligence, heredity, defects, place in music, and norms for vocational and avocational guidance.

II. The Physical Basis of Pitch

Vibration frequencies. Pitch depends upon the frequency of vibration in the sounding body and is designated with accuracy in terms of the number of vibrations per second. Thus, a′, international pitch, is 435 double vibrations per second. There has been much confusion in terminology from the fact that the French have used the term "vibration" to designate a phase of a vibration, whereas the more general practice, which is that followed here, is to make it represent a double vibration — that is, the complete oscillation of the sounding body both to and fro. This is usually abbreviated d. v.

The tuning fork. The physical basis of pitch may be illustrated with a tuning fork, which is the most accurate means we have for the production of a tone. A good tuning fork, under favorable conditions of temperature and energizing, has an accuracy that is fine enough for all purposes of pitch investigation and will hold its pitch indefinitely.

The graphic record. For many purposes it is convenient to use a graphic tracing of the vibration. By drawing a vibrating fork with a fine point attached to one prong over

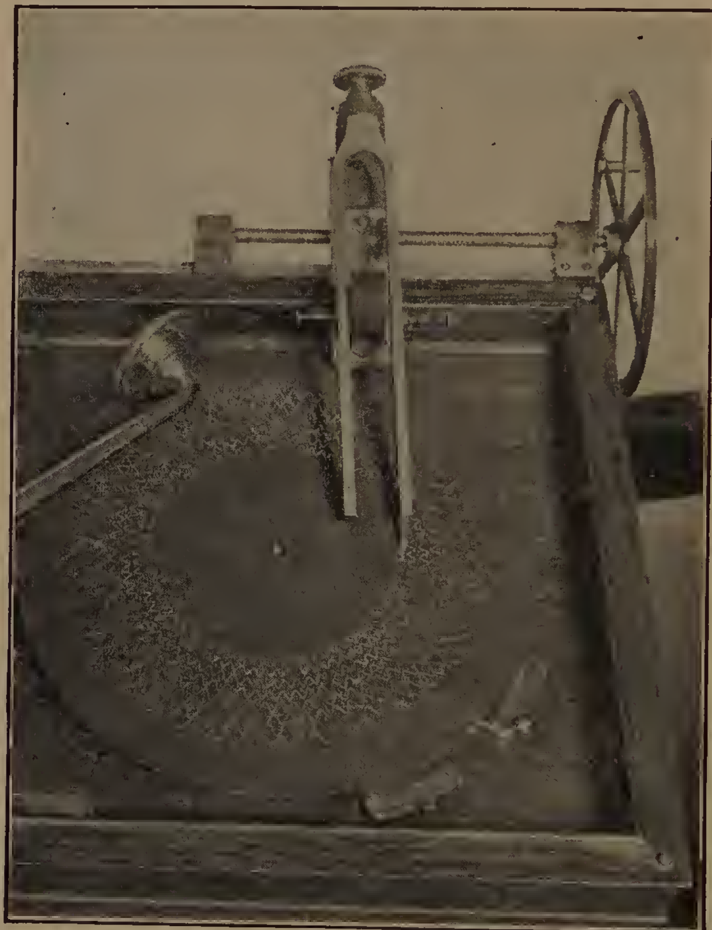


Fig. 1. — How to Make a Graphic Record of the Vibration of a Tuning Fork.

A glazed paper coated with candle smoke revolves at a uniform speed on the phonograph. The electrically driven fork is mounted on an endless screw, which may be turned by the crank wheel at the corner so as to spread the record over the disk. This fork is 100 d. v.

a sensitive surface we can secure a wave-tracing in which it is possible to measure the form, the amplitude, and the number of waves per second, or rate. In making such a graphic

record it is customary to drive the fork electromagnetically and to make the tracing on a moving smoked paper. Figure 1 shows such a tracing on a smoked paper revolving on the phonograph table. We may here count the number of waves per second, either roughly by timing the machine to exactly one revolution per second and counting the number of waves per revolution; or, more exactly, by passing an electric spark through the tracing point so as to make dots in the wavy line exactly one second apart. To get a correct idea of the sound wave from this fork, we should think of a prong of the fork as a pendulum suspended before the ear and causing air vibrations in the outer ear by its swinging to and fro.

All tones may be recorded. All tones can be studied objectively by recording, through various means, the rate, the amplitude, and the form of the physical vibration, but it is not necessary to discuss here the methods employed in the recording, measuring, objectifying, and magnifying of the vibration from string, reed, pipe, vacuum, membrane, voice, or other means.[1]

We hear pitch, not vibration. While all music is objectively due to physical sound waves, we must bear in mind that we can never be directly aware of the rate of vibration as such, for we hear it as musical pitch. This is one of the wondrous transformations "from matter to mind." Out of mere vibration is built a world of musical tones which do not in themselves suggest vibration at all. Yet the human ear may be so keen as to detect in nature a difference of one-fifth of a vibration in terms of pitch. It is fortunate

[1] Those who are interested in this aspect of the subject will find "The Science of Musical Sounds," by D. C. Miller, The Macmillan Co., a most excellent recent treatise.

that we can live in a world of music without thinking at all of the physical counterpart; still for the science of music and for the study of musical talent such reference is necessary.

III. The Physiological Basis of Pitch

Two groups of theories. No theory of the anatomy and physiology of the pitch-differentiating mechanism in the ear has been fully established. There have been until recently two divergent types of pitch theories. One has maintained that there is a mechanism in the ear which differentiates pitch; this is often spoken of as the harp theory. The other has denied the existence of such mechanism and asserted that the differentiation takes place in the brain; this is generally spoken of as the telephone theory.

The harp theory. The former of these two theories now prevails. But there are many divergent theories as to the location and the mechanism of such harp structure. Early investigators maintained that the basilar membrane serves this purpose; but, in recent years, a tendency has developed to ascribe this function to the tectorial membrane. In both cases we find divergent opinions as to the actual method of functioning in these harp structures. All the harp theorists are agreed that one of these structures (and some maintain both) is capable of being tuned to as many pitches as the human ear can hear; so that, when a particular vibration frequency is conveyed to it by the liquid of the inner ear, a particular film or segment of it will vibrate because tuned to that frequency, and other parts will remain quiescent. All theorists are also agreed upon the fact that the end organ of hearing is the spiral layer of hair cells which is so located that it will be physically stimulated either by

the fibers of the basilar membrane acting through the rods of Corti, or by the strands on the tectorial membrane, acting by the leverage of the hairs projecting from the hair cells. The mechanical shaking produces a chemical change in the cell, which results in a nerve impulse that is transmitted over a special nerve fiber from that cell to a particular part of the brain.

The essential assumption. The ear is a most wonderful mechanism with its membranes, levers, and liquid conductors carrying the vibration to the harp structure, its means of analysis of all pitches in that structure, and its means of transmission of each pitch over its particular line to the brain. We cannot here undertake to discuss the structure of the ear, its physiology, and the numerous technical problems or theories of hearing. The reader who is interested in this phase of the subject must turn to books on the anatomy and physiology of the ear. But for psychological purposes it is necessary to make certain assumptions, of which the essential one is that there is a pitch-differentiating mechanism in the ear which is so organized that it is capable of serving as a physical basis of the sensory phenomena with which we deal in the psychology of hearing: namely, pitch, intensity, timbre, volume, fusion, and consonance, and their derivatives or variants. For pitch, the harp theory furnishes at least a good analogy.

IV. The Lowest Audible Tone

Upper and lower limits of tone. Sound waves are merely waves, not sounds; they may be of so low a frequency that they do not produce sensations of tone, or of so high a frequency that the ear does not respond. We must examine these two limits of the ear in turn.

How to measure the lower limit. To measure the lower limit of tonality we employ an adjustable fork, Figure 2. The disks are made of hard rubber or of asbestos board 100 mm. in diameter and 7 mm. thick. The quality of the material and the thickness of the disk insure real smoothness and regularity of the waves. This size and shape have been found by experiment to produce the most favorable form and volume of the wave. The large size of the fork makes possible a large amplitude of vibration which is necessary at the lowest limit. To vary the pitch, we may vary the position of the disk which acts as a weight, or we may use a series of forks permanently tuned. The latter method is preferable.

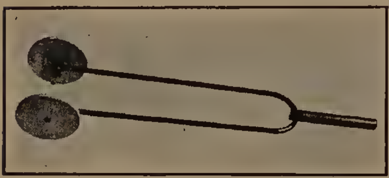


Fig. 2. — A Lower Limit Tuning Fork.

Adjustable for a pitch from ten to thirty vibrations.

Variables. The lowest audible tone (the slowest vibration frequency that will produce a tone) varies with the intensity, the duration, and the timbre of the tone. In terms of a sounding instrument, such as the tuning fork, the principal conditions are essentially the amplitude, or extent of oscillation of the disk, the size and shape of the disk, its proximity to the ear and its position before it, the length of time it vibrates there, and the form of the vibration. In making measurements we aim to select the most favorable conditions and to control these by keeping them constant. Thus, a standard procedure would maintain the standard fork vibrating for five seconds with an amplitude of 10 mm., the center of the disk being as close to the opening of the ear as is possible without touching the lapel of the ear.

Character of lowest audible tone. Under these conditions the normal ear in good condition can hear a tone of 14 d. v., and in rare cases as low as 11 or 12 d. v. This tone seems very massive and distant and is ordinarily accompanied by overtones which one must learn to eliminate in listening. Below this limit one hears individual puffs which refuse to blend into a tone. Just above this limit one still hears these puffs. And at the same time one hears the tone quite as if the two experiences came from different sources.

Some laws. It has been shown by experiment [1] that this limit varies inversely with the area of the vibrating surface; that is, if smaller disks were used the tone would have to be higher in order to be heard: the necessary amplitude of vibration varies inversely with the area of the vibrating surface. The limit varies inversely with the amplitude of vibration; that is, if the amplitude is less than 10 mm. of the standard disk, the vibration must be more rapid to produce a tone. The necessary distance varies directly with the pitch; it also varies directly with the area of the vibrating surface. The lowest audible tone can be heard but momentarily, usually not before one or two seconds after the exposure and then only for a second or two.

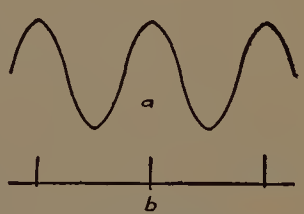


Fig. 3. — The Significance of Wave Form in Low Frequencies.

Dependence upon wave form. How this limit may be varied by the altering of one of these conditions may be illustrated by the fact that the wave form produced by a spark, for example, may not lead to tonal fusion at less than 100 d. v. The reason for this is shown in Figure 3, in which *A* repre-

[1] Thomas F. Vance, "The Lower Limit of Tonality," Univ. of Iowa, Stud. in Psychol., 1914, VI.

sents the wave from the tuning fork that can be heard at 14 d. v., and *B* the wave from the spark that does not fuse completely into a tone even at 100 d. v. Musical tones are usually of the first order. Indeed the slow rolling wave form of the long pipes of the organ and other strong, low vibrations are very favorable for fusion into tone. As a matter of fact, in the large organ and the large horn, tones as low as sixteen vibrations can be depended upon for musical effect. Tones below the limit of hearing, for example, 8 d. v., may be used for musical effect on account of their enhancement of the tactual impression as well as for their overtones and, possibly, difference tones, which may be heard.

Effect of age. There is no experimental evidence to show that the lower limit of tone hearing varies with age. The experimental observation of these tones requires a certain amount of information and development of understanding and power of application which comes with age. But this does not signify that the ignorant and immature do not actually hear these tones and are not musically affected by them precisely as in the practical use of language they are guided and affected by fine distinctions without being conscious of them as such. The individual differences in the lower limit of tonality are traceable to lack of information and of training in observation, and, in many cases, to the lack of a musical mind rather than to any structural condition in the ear. Many bright, normal persons cannot make any intelligent observation of musical tones of any pitch. There is no evidence to show that musicians as a class have any marked superiority or ability in hearing low tones on account of their training in music.

V. The Highest Audible Tone

The Galton whistle. The Galton whistle, Figure 4, is a piston pipe which Sir Francis Galton first devised for the testing of the hearing of animals in the zoölogical gardens. He attached the piston to his walking stick, pushed it into the cage, and, by squeezing an air bulb, produced a tone higher than he himself could detect, and then observed whether or not the animal responded to it. He learned that animals could hear sounds so high as to be inaudible to himself.

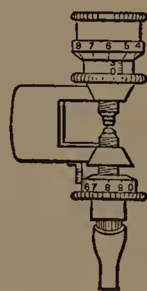


Fig. 4.—The Galton Whistle.

Not yet reliably measured. Measurement of the upper limit of pitch is as yet very unreliable. No one has succeeded in determining under ordinary conditions the maximum efficiency in form, volume, amplitude, and duration of vibration for the highest audible tones; and we know now that the upper limit varies with each altered conditions within wide limits. Intensity seems to be the chief variant; the louder the tone, the higher it can be heard. As in the lower limit, the form plays a rôle, but we do not know in what direction. It is probable that the highest tone, like the lowest, can be heard only momentarily. Various types of instruments have been tried, such as the tuning fork, the tuned cylinder, and the reed, but none of these is entirely satisfactory. The Galton whistle, though not the most reliable, is still the most common instrument used. It will be necessary to employ some other means of sound production, probably the speaking arc, the induction wave from a high-frequency oscillator, or some similar form of loud- and high-tone producing instrument, in which the

factors can be varied and controlled to meet the situation. Experiments on these principles are now in progress. Although there is wide disagreement, it may be safe to estimate from the data available that the very good human ear can hear a tone as high as thirty or forty thousand vibrations, or more, when young; but in support of this we have as yet no reliable measurement. The latest experiments reported place the limit at twenty-four thousand vibrations, but they are probably not reliable.

Decline with age. It is certain that this upper limit varies greatly with age and with individuals of the same age. Roughly, it may be said that, if the upper limit is 30,000 d. v. for a person of sixteen, it is quite probable that it will be reduced to 15,000 d. v. by the age of sixty. This decrease with age seems to be quite independent of training and of the use of the ear. It is undoubtedly in accord with the biological law that the most delicate structures are the first to suffer decline with increasing callousness from age. This law of decline applies also to other weakening forces than age, such as disease, or injury, and therefore accounts in large part also for the great differences we find among different persons of the same age.

Quite independent of musical training. This upper limit probably does not depend upon musical training to any great extent. It is a direct function of the structure of the inner ear, depending upon the condition of the part corresponding to the short strings on the harp, which are the first to harden or get injured because they are the most delicate.

Some personal experiences. The author has had a very interesting personal experience with this in teaching. In his earlier years he could usually hear as high a tone as any

of the students in the room when demonstrating with the Galton whistle before a class; but now he has reached the humiliating stage of hearing nothing while perhaps four-fifths of the class hold hands raised to signify that the tone is heard, this notwithstanding the fact that he has the advantage of sounding the tone near to his ear. The same situation arose in a rather embarrassing episode when one of the greatest singers in the country was being tested in the laboratory with her young daughter. The daughter was responding to higher and higher tones, and the mother not hearing anything was astonished and could hardly be made to believe that her comparatively untrained daughter's ear should hear so many high notes which she, the great singer herself, could not hear. A distinguished organist was present at the demonstration of the highest audible tone by means of the speaking arc, and was baffled by the fact that the majority of the audience gave evidence of hearing clearly the high tones which were being demonstrated while he with his superior musical ear could hear none. He was sixty-five years old. Here was a crucial test of what may actually happen and does happen in listening to music. That the highest pitch level is ordinarily the first to be injured in cases of ear troubles is shown in our diagnosis of hearing defects in the otological clinic.

Musical significance of this change. Musically, the significance of the variation in the upper limit is of far-reaching consequence. Few instruments employ these high notes in themselves, but, as we shall see later, the character of musical tones is determined by the presence of overtones and the number of overtones one can hear varies with the upper limit of tonal hearing; that is, the lower the upper limit, the more high overtones are eliminated by this

limitation. For this reason, rich tones, such as those of the human voice or of the violin, produce a different clang for young and old according as one can hear the high components and the other cannot. The fact that we fail to hear very high tones in old age or in the decline of the upper limit from other causes, is, therefore, quite insignificant in comparison with the fact that under this condition all tones sound different from what they would if the high overtones were perceptible.

VI. The Measurement of Pitch Discrimination

Pitch discrimination. The capacity for the hearing of differences in pitch is called pitch discrimination. This is a fundamental capacity in musical talent, and upon it rest most of the powers of appreciation and expression in music. One must hear pitch differences in order to appreciate tones. One must be guided by such hearing in playing and singing. The imagining, the remembering, the thinking about, and the arousal of feeling for tones are all limited by the capacity for hearing differences of pitch. Knowledge about pitch discrimination is, therefore, one of the most basic facts in the psychology of music, certainly the most important factor in the hearing of pitch. Ordinarily, this is what we have in mind when we speak of "tonal hearing."

The pitch-discrimination forks. The sense of pitch, in terms of pitch discrimination, can be measured by means of a series of tuning forks like that in Figure 5, used with the resonators. These forks are of a high grade of workmanship and are tuned in a differential series in which the standard is a′, 435 d. v., which is known as the standard in international pitch, and the ten increment forks vary

from this and are higher in pitch by the following steps: ½, 1, 2, 3, 5, 8, 12, 17, 23, and 30 d. v., respectively. For very precise work a special set of forks with increments of .2, .4, .6, and .8 d. v., respectively, is used. It is well to remember that at this level, a′, 435 d. v., one vibration is equivalent to one fifty-fourth of a tone. The measurement may, therefore, be thought of as stated in fifty-fourths of a tone.

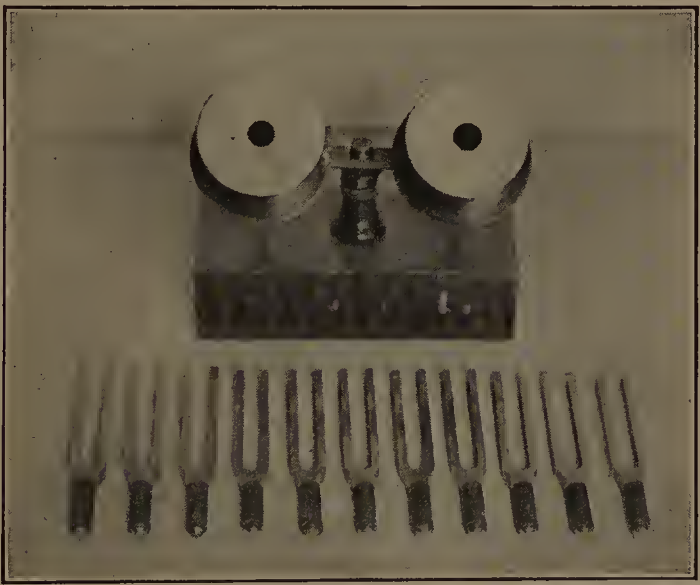


Fig. 5. — A Set of Pitch-Discrimination Tuning Forks with Resonators.

Procedure. The standard fork and one increment fork are sounded in quick succession in front of a resonator, the order in which they are to be taken being determined by chance. It is best to use two resonators, one for ½–12 d. v. and the other for 17–30 d. v. The problem of the listener is to tell whether the second tone was higher or lower than the first. Thus, the problem is reduced to its simplest form; the listener simply has to record H or L according as he

thinks the second is higher or lower than the first; and, if he does not know, he is required to guess, because all the methods now employed in measurements of this kind take into account the operation of the laws of chance.

The technique of procedure in the measurement is described fully by the author elsewhere.[1] Those who propose to use this test should consult the former of these reports, which is a report of a committee from the American Psychological Association on the standardizing of mental tests.

The group method. There are various methods of procedure depending upon the facilities for experiment and the purpose to be served. The following method is best for the testing of groups of individuals, for example, a parlor circle, a schoolroom, or even a whole assembly room of school children *en masse*.

The trials are made, one for each increment in the order of magnitude from the largest, 30 d. v., to the smallest, $\frac{1}{2}$ d. v. This series is repeated at least twenty times, yielding two hundred trials in all. The record is then checked by a key showing what the answer should be for each trial. The number of mistakes is counted and this is subtracted from the total number of trials to obtain the number of right answers. The number of right answers reduced to a percentage gives the "per cent right."

Norms. This original record in itself would have but little meaning, but we may interpret it in several ways to give it meaning and objective reference, particularly in terms of percentile rank, vibration difference, fraction of a whole tone, and frequency of distribution. An example of norms

[1] "The Measurement of Pitch Discrimination," *The Psychol. Monographs*, 1910, No. 53, Princeton, N. J.; also "The Measurement of Musical Talent," *The Musical Quarterly*, 1915, I.

for each of these interpretations is given in Table I, which is based on the records of 1265 university students in or above the sophomore class.

TABLE I. NORMS OF THE SENSE OF PITCH FOR ADULTS

PER CENT RIGHT FORKS	PER CENT RIGHT DISKS	VIBRATION DIFFERENCE	PART OF TONE DIFFERENCE	PER CENT RANK
100	94	0.25	.005	100
95	90	1	.02	97
90	86	2	.04	80
85	81	3	.05	52
80	77	5	.10	32
75	71	8	.15	18
70	66	12	.22	10
65	62	18	.33	6
60	57	25	.46	3
55	53	34	.63	1

Table I. Table I gives a comparison of certain items of per cent right, least perceptible difference, and rank. For example, if a man has 100 per cent right in the record with pure tones, or 94 per cent with rich tones, he is capable of hearing a difference of one-fourth of a vibration, or .005 of a tone at a′ under most favorable conditions with these tones in 75 per cent of all trials, and his rank is 100. Each of the remaining lines of the table may be read in the same way. By reference to this table one can tell at a glance what a given per cent right in a record means in terms of vibration difference or difference in part of a tone as expressed in columns 3 and 4 respectively. Detailed tables for converting per cent right into rank are furnished with the instructions accompanying the phonograph disks.

Comparison of pure tones and rich tones. The first two columns show that with a given block of differences

it is possible to get a higher per cent of right answers when the tones are produced with tuning forks before a resonator, than when produced by the phonograph; that is to say, the phonograph test is more difficult than the tuning fork test. This may be due to several factors which have not yet been analyzed. Of these the difference between the pure tone and the rich tone is probably primary, but further experiment will undoubtedly reveal other factors. This difference does not, however, invalidate either test material so long as we use separate norms for the two kinds of tones. In other words, a person will get the same rank whether measured with pure tones or rich tones, provided the appropriate norm is used.

Percentile rank. Since, by the method employed, one-half of the answers will be right by chance, our per cent right may occur from 50 to 100, as listed in the first column of the table. The percentile rank, as given in the last column, is found by arranging all the records in the order of excellence from the best to the poorest and dividing these into one hundred groups, as described in Chapter I. This percentile rank becomes the record for general use in reporting measurements and is very valuable because it enables us to interpret our own achievement in comparison with those of others of our own kind. The record is expressed objectively as "the least perceptible difference," "threshold," or "increment" in terms of vibrations in the third column, and in terms of fraction of a tone in the fourth column.

Standard of certainty. In determining the least perceptible difference it is conventional in psychology to use the unit at which we can make 75 per cent of our answers right as a standard; that is, we assume that we

perceive the difference when we are able to give a correct report in 75 per cent of the trials. Thus, when we say in Table I that the threshold for 90 per cent right is 1.0 d. v., or .02 of a tone, this means that we can perceive the stated difference in approximately 75 per cent of our trials with the disks.

Table I and Figure 6. The data of Table I are represented graphically in Figure 6, in which, for the sake of clearness, only every fifth step is given. Such picture conveys at

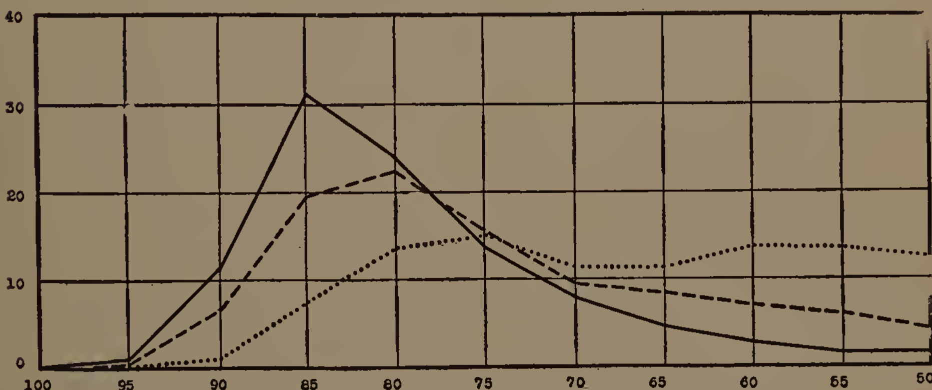


Fig. 6. — Distribution of Capacities in the Sense of Pitch.
Based on the phonograph record Number A7536.

Solid line, adults; dashes, eighth grade children; dots, fifth grade children. The numbers at the bottom denote per cent right; the numbers at the left the per cent of cases for each level.

a glance the relative distribution of capacities and the relative difference in the magnitude of these capacities for different age levels. Table I with Figures 6 and 7 are here given as typical forms for the representation of norms in all our talent tests.

Figure 7. It is convenient to represent the conversion of records in terms of an ogive as in Figure 7, in which the conversion from per cent right to percentile rank is given in a single picture for three norms. In this figure we may

obtain the equivalent percentile rank in any of the norms for any per cent right by running the eye vertically from the given per cent right indicated at the bottom to the norm desired and thence horizontally to the scale in the left mar-

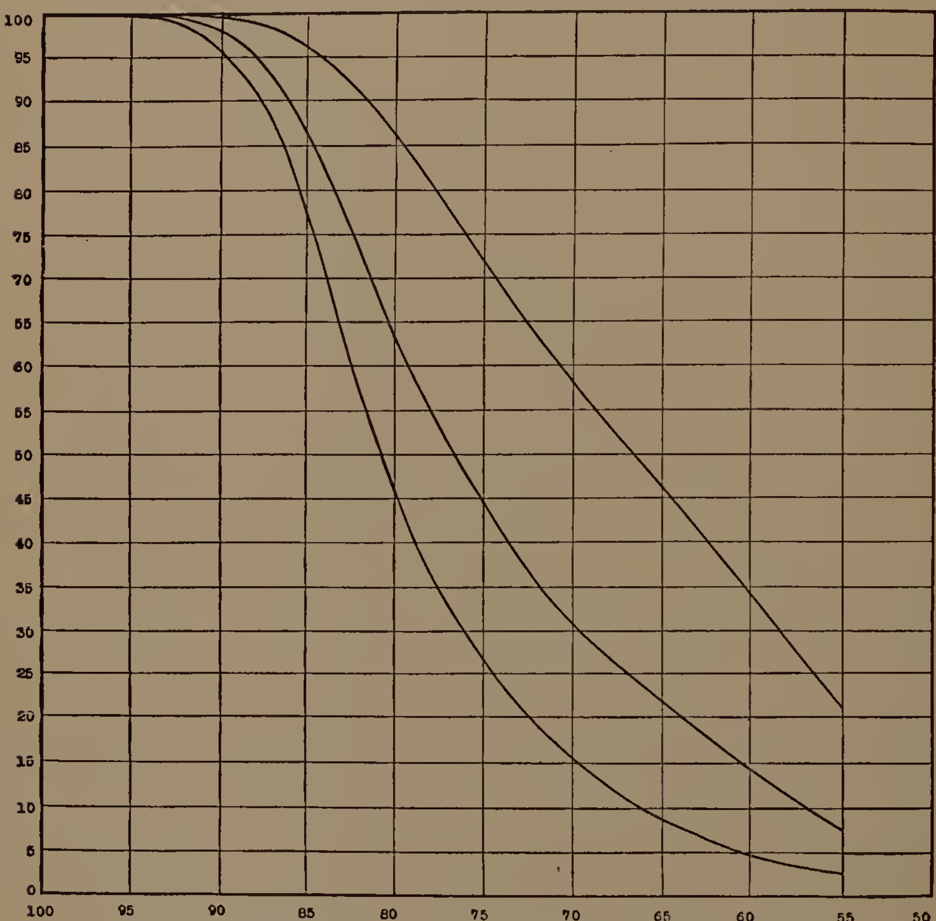


Fig. 7. — **Norms for the Converting of Per Cent Right into Rank.**

The middle norm represents eighth grade children; the one above, fifth grade children; the one below, adults.

gin which indicates the percentile rank. Thus, a ten-year-old child in the fifth grade, who has 80 per cent right, gets a percentile rank of 86, whereas an adult with the same record would rank 46.

Norms for other ages estimated as proportional. Children of the sixth and seventh grades may be assigned proportional rank between the fifth and eighth grades. Likewise high school students may be assigned proportional rank between the eighth grade and the adults; for example, in pitch 75 per cent right for the sixth grade would be a rank of 63; for the seventh grade 54; for high school freshmen about 39; and sophomores 33. High school juniors and seniors may rank as adults.

The advantage of such norms. The advantage of such norms is clear: whenever and wherever we measure any person under the conditions which the norm represents, we can tell instantly what his rank is in a community of his kind and what the rank means in terms of vibration difference, tone difference, or commonness of occurrence.

"**Smoothing.**" In the above table and graphs, the figures and curves have been "smoothed" in the conventional manner in order to correct for irregularities which occur in a finite number of cases.

The individual method. If we are examining a single individual, the test may be made more intensive and exact. In that case we first skirmish about to find for what difference the observer is likely to get about 75 per cent right. We then take a large number of trials at that step and use conversion tables [1] by which we may convert the record on that step into a step which will yield 75 per cent right; for example, 69 per cent right for 1.0 d. v. means that, to get 75 per cent right, the difference must be 1.3 d. v. This is the principle on which the data in columns three and four were obtained. The record in terms of vibrations is abso-

[1] E. B. Titchener, "Experimental Psychology," *Qualitative, Instructor's Manual*, p. 288, The Macmillan Company.

lute; that in terms of a fraction of a tone is relative. Thus, 1 d. v. at a′ is $\frac{1}{54}$ of a tone; at a″ it is $\frac{1}{108}$ of a tone; at a‴ it is $\frac{1}{216}$ of a tone.

This procedure typical. This measurement of pitch discrimination may be regarded as typical of what we do or aim to do in the scientific study of talent by the experimental methods in the psychology of music and musical guidance. The measurement is quantitative. It is accurate enough for all practical purposes, and it can be repeated, described, and controlled, and the degree of its reliability can be stated quantitatively. The result can be shown in a simple picture. Comparison can be made for the same individual under different circumstances, and with different individuals under the same circumstances. The record may then be used as a basis for practical guidance. It will, therefore, be of interest to treat it in some detail as an example of what may be done in each of the other measurements which follow. The fullness of this discussion will enable us in later sections to pass with a mere mention the things which other tests have in common with this one.

VII. Individual Differences

Magnitude of differences. With this technical comprehension, we are now in a position to understand the interesting and realistic story of the distribution which Figures 6 and 7 tell so graphically. "Ears" may vary from the extremely good to the extremely poor. One person may hear a difference of $\frac{1}{4}$ d. v., less than 1/200 of a tone, whereas another may not be able to hear any smaller difference than a half tone, or even more; counting $\frac{1}{4}$ d. v. as the best and 50 d. v. as the poorest case observed, it appears that one may be at least two hundred times as keen as another in this capacity.

This magnitude of differences becomes more striking as we compare it with physical differences such as differences in height, weight, form, strength, and color. If one man is twice as tall as another that is regarded as a remarkable difference. By the very magnitude, these differences in pitch discrimination must play an important rôle.

Comparison of group and individual records. The distribution in Figure 6 is based on group measurements under favorable conditions in a single one-hour test of a class. Such group tests are used as "dragnets" for preliminary and rough work. One cannot expect, of course, to get so fine or so reliable a test in a class as in an individual test. The norm for individual tests is, therefore, somewhat lower than that here given, but the general form of the distribution of cases is the same.

VIII. The Physiological *versus* the Cognitive Limit

Nature of the physiological limit. The bed-rock limit of a natural capacity of this kind we call the physiological limit. We always aim to reach this physiological limit; but it is not always possible to attain it, and we must content ourselves with the cognitive limit, which means an inferior record due to some difficulties or disturbances, such as distraction, ignorance, and lack of power of application. We designate the limit as cognitive, because these difficulties are essentially of a cognitive nature — difficulties in knowing rather than lack of capacity. Since the physiological limit is one which cannot be reached in all trials, even under favorable circumstances, we usually content ourselves with a "proximate physiological limit" which means that it is near enough to be of service.

Reaching the physiological limit. A successful experi-

menter can reach the proximate physiological threshold in this measurement within a half-hour's trial in about three-fourths of all cases. In the remaining one-fourth, he must either suspend judgment or proceed with special methods to eradicate the difficulty, which can be done with all persons reasonably well developed mentally, although the process often requires great patience and ingenuity. As a rule, those who have keen ears for pitch discrimination reveal the physiological limit at once, regardless of age, training, or general brightness.

Limit not a sharp line. The conventional threshold here used is based on a record of 75 per cent right when the observer is allowed to guess if in doubt. This means that in some cases the answer was right by chance, and in other cases he could possibly have heard smaller differences on account of the fluctuation of attention to liminal sounds. Fifty per cent right would mean "no ability to hear the difference." We must not, therefore, think of threshold as a sharp or invariable limit. It is a scientific convention to denote a defined degree of certainty.

IX. Relation to Age

The physiological limit does not improve with age. The physiological limit of pitch discrimination does not vary with age. This is a far-reaching statement, but it bears out the popular adage that if a person is to have a fine ear he must be born with it. Indeed, as we have seen for upper limits, it is probable that the neural apparatus for pitch discrimination actually declines with age on account of the growing callousness of tissue, but of this we have no experimental proof within the middle tonal range.

Comparison with vision. This fact of absence of improve-

ment with age is quite analogous to the situation with keenness of vision. The child at five can see as far and as keenly as his father can, provided the test is not one of information. The child can tell as well as the father can, for example, whether the object in the distant road is one horse or two horses; that is, his eye is likely to be as keen as the father's or keener in a fair test of keenness of vision. But if, as the horse approaches, one ask him to see if it is a roadster, of what breed, of what gait, of what defects, — any one of scores of points which the father who is an expert judge of horses can see, — the child would bear no comparison. He has not yet secured the information or developed skill in the recognition of fine distinction; yet one may rightly say that the child has as good vision, or "eye," as he will ever have. With this eye his intellect may learn to do wonders. Eyes differ; even in childhood they may vary from the perfect to the blind. The degree of vision determines to a large extent the character of intellectual acumen.

What this means. Exactly so it is with hearing. There are differences in the quality of the psycho-physic ear for pitch. So far as ear is concerned, the child at five can probably hear as well as he ever will, and one important element in hearing is pitch. If we test pitch hearing without testing range of information or special skill, we find that the child can hear pitch as well as the adult. But if we test, or inquire about, pitch complexes, he cannot compare with the educated adult. A child can tell as well as an adult which of two tones is the higher if he understands what is meant by higher; but ask about the pitch of overtones, and the young child would be comparatively helpless.

Nature of training. In other words, there are countless things to learn through the sense of pitch; there are count-

less possibilities for the acquisition of skill in the art of analyzing pitch complexes and in the ability to use the ear in tone production. The possession of a fine ear in early childhood offers no excuse for omitting ear training; but we should perhaps call it mind training, if there is any danger of thinking that we are improving the ear. At best, the ear is like a violin; it is good for it to be in artistic use, but the range of improvement must be small. What the violin shall do depends upon the master stroke; so what the ear shall do depends upon the musical "soul."

Cognitive limits. There are, indeed, marked variations in age among children as to the ability to give evidence of this capacity. The old records of pitch discrimination made it appear that this capacity improves with age. But those records dealt with the cognitive limit; the variation was due largely to inadequacy of measurement and lack of skill on the part of the experimenter. With a child who has a musical ear one may obtain a reliable measurement as early as the age of five, and even earlier. Mental dullness and possession of a relatively poor ear requires more maturity for the reliability of the measurement. At least 90 per cent of all children can be measured satisfactorily by individual tests at the age of eight.

Ingenuity in testing young children. In testing young children one must show ingenuity in adapting the test to the child's knowledge or skill. We often, for example, find that it is difficult to make him understand what is meant by high or low. We may then resort to the device of asking him to sing the tone he hears. He will, as a rule, exaggerate the differences, which makes it easy to hear whether he is trying to sing high or low.

School grade rather than age. The grade in the public

school rather than age is used in our norms, because the reason for variation with age lies not in chronological age, but rather in school age, or stage of advancement, which is perhaps fairly represented by school progress. The average age for the fifth grade in our records is 10.1 years, the youngest being 7 and the oldest 17. For the eighth grade it is 14.2 years, the youngest being 10 and the oldest 20.

Summary. The differences we find for age in the above records, Figures 6 and 7, are accounted for by the handicap the younger child has in responding to the conditions of the tests in a group. When we test children individually and are in a position to simplify the conditions, we obtain practically the same norm for children as for adults. That is, they distribute like adults, provided they are old enough to understand the test and sufficiently developed to apply themselves to the task.

"Reduced to its lowest terms, the question of variation with age may be interpreted to mean that we have no evidence of improvement in physiological limit of pitch discrimination with age; a young child of school age and even younger, can hear pitch fully as keenly as an adult. The amount in favor of the adult shown in all group statistics is amply accounted for by the difficulty in making a reliable test on the young and by their lack of information. This statement is based primarily on two lines of evidence, — the common occurrence of fine, irreducible records among young children, and the character of the conditions which are ordinarily overcome by instruction and training." [1]

[1] F. O. Smith, "The Effect of Training in Pitch Discrimination," Univ. of Iowa, Stud. in Psychol., 1914, VI.

X. Relation to Sex

Boys and girls about equal. Pitch discrimination does not vary with sex. The following quotation summarizes the result of our investigation on this point. "Pitch discrimination does not vary with sex to any significant extent. In the records here reported and in many hundreds of other records in this laboratory, in which comparisons may be made for sex, certain tendencies are shown in groups of records, sometimes in favor of one and other times in favor of the other sex; but, on the whole, it seems certain that such differences, except so far as they are due to selection in grouping, may be accounted for as due to the conditions of the test rather than to the sex difference in the psychophysic capacity of pitch discrimination. Thus one of the most consistent and striking differences reported above, that of the superiority of elementary schoolgirls over elementary schoolboys, may probably be fully accounted for by the prevailing trait of aloofness of the preadolescent boy toward music. These boys often regard music as a sort of frill for girls and, therefore, enter the test with less fervor than do the girls. Such interpretation is supported in part by the fact that in the high school and in the university, where the girls have had far more advantage of training than the boys, the records reveal no appreciable difference for sex." [1]

XI. Relation to Intelligence

Slight dependence upon intelligence. Pitch discrimination can in no sense be used as a test of intelligence, for the physiological limit of pitch discrimination, the "ear," does not vary with intelligence for normal individuals. The

[1] Smith, *op. cit.*

extremely dull person is, of course, more likely to give a cognitive limit than the bright person in the first measurement, but keen intelligence is by no means a guarantee of keen tone discrimination. This agrees with the fact that some of the most sensitive and responsive musicians find but little interest in intellectual pursuits; and that some great intellects are notoriously devoid of a "musical ear." Pitch discrimination is not a matter of logical judgment. It is rather an immediate impression, far more primitive than reflective thought, and dependent upon the presence or absence in various degrees of the sensitive mechanism in the inner ear.

Evidence in school children. This statement is based upon evidence from various angles in many thousand cases of examinations. One illustration may be given. In surveys of children in the public schools the teachers best acquainted with the children were asked to confer and to grade the children in brightness, which was defined as "the average natural ability to do school work when favorably disposed and under favorable conditions." That is, the grade was not to be based upon school records but upon estimate of ability to do the work "if he had a mind to," that is, tried. The grading was done on the following scale:

A, the best 10 per cent.
E, the poorest 10 per cent.
B, the 20 per cent just below the best 10 per cent.
D, the 20 per cent just above the poorest 10 per cent.
C, the remaining 40 per cent.

Table II. The records on pitch discrimination were then arranged on the same scale and the two were combined into a quintile table, as in Table II. This table shows to what

extent brightness is related to pitch discrimination. The small figures in italics show what the distribution would have been in the long run if there were no relationship between the two factors. The black-faced figures show what the distribution would have been if there were complete correlation between brightness and keenness in pitch. A comparison of the actual figures shows that there is a slight

Table II. Correlation of the Sense of Pitch and Brightness

Pitch

% Rank	A 100–93	B 94–79	C 78–55	D 54–13	E 12–1
Brightness A	**(10)** *1* 1.9	*2* 2.1	*4* 5.0	*2* 2.1	*1* .2
B	*2* 2.1	**(20)** *4* 5.1	*8* 8.4	*4* 2.3	*2* 1.1
C	*4* 4.2	*8* 8.7	**(40)** *16* 14.4	*8* 7.1	*4* 2.4
D	*2* 1.4	*4* 3.0	*8* 7.6	**(20)** *4* 5.3	*2* 3.3
E	*1* .2	*2* 1.1	*4* 4.4	*2* 3.2	**(10)** *1* 2.8

The black-faced figures show what the distribution should be if pitch discrimination were exactly proportional to "brightness."
Italics show what the discrimination should be if there were no agreement between these two factors.

tendency toward relationship. This may, however, be accounted for by the fact that, in a group of this sort, some children are so backward mentally that they are not able to do credit to their actual psycho-physic capacity. We have also to take into account the fact that, if a child is bright in music alone, this consideration would tend to improve his rating on general intelligence.

XII. The Effect of Training

The physiological limit does not improve with practice. The sensitiveness of the ear to pitch differences cannot be improved appreciably by practice. When a person shows a cognitive threshold, practice ordinarily results in a clearing up of the difficulties which are in the way of a true measure of discrimination by information, observation, and development of interest, isolation of the problem in hand, and more consistent application to the task in hand. This is, of course, not improvement in the psycho-physic ear but merely a preliminary to a fair determination of the psycho-physic limit. It follows that instruction in regard to the nature of the test and individual help in adjustment to the test are important for the lowering of the cognitive limit and that mere practice for this purpose is a poor and uncertain makeshift. It also follows that a "cognitive" threshold is no measure at all but rather a confession that the measurement has not yet been successfully made.

"Training in pitch discrimination is not like the acquisition of skill, as in learning to read or to hear overtones. It is in the last analysis informational, and the improvement is immediate in proportion to the effectiveness of the instruction or the ingenuity of the observer and the experimenter in isolating the difficulty."[1]

Evidence. The evidence for this position is cumulative from different sources. If we take one hundred parents and compare them with one hundred of their children from eight to twelve years of age, the children will do fully as well as their parents in pitch discrimination. We find that, aside from the operation of selection, the musically unedu-

[1] Smith, *op. cit.*

cated reveal as keen a pitch discrimination as the musically educated. In so far as it has been possible to carry the test over several years the records show that if an accurate expert measurement of the pitch discrimination of a pupil before entering upon musical education be made and repeated annually, the record will not change materially with training.

First proof. This surprising fact was first established by Buffum,[1] who classified twenty-eight eighth-grade pupils in a preliminary fifteen-minute individual test for each one and then proceeded to train them by requiring forty minutes of the most specific and intensive practice under favorable conditions for twenty successive days, recording the average achievement for each day. The result was greatly surprising. Instead of showing progressive improvement with practice, each child remained as rated in the preliminary test, with only two exceptions, and the average ability for the class was the same at the end of the twenty days of this intensive practice as at the beginning.

Summary of training. On the basis of such evidence in experiment the author published, in 1910, the following summary:

"At this preliminary stage, the following general conclusions may be stated:

"(1) When the proximate physiological threshold has been reached, practice is of no avail. (2) So long as a cognitive threshold prevails there is prospect of improvement by practice to the extent that the cognitive is above the physiological limit. (3) This improvement is usually

[1] As reported by the author in "The Measurement of Pitch Discrimination," *Psychol. Monog.*, No. 53.

very rapid, often immediate and can usually be traced to the acquisition of knowledge, through experience or information about what pitch is, as distinguished from other attributes of tone. (4) In the majority of cases it is possible for the ingenious experimenter to discover the proximate physiological threshold to a fair degree of certainty in a well-planned half-hour individual test, or in one heterogeneous and one homogeneous group test of one hour each; and, for most of the cases in which this fails, the same tests demonstrate positively that the threshold is only cognitive. (5) The possibility of reaching the physiological limit in a single test depends to but very slight extent upon whether or not the person tested has had musical education; it is mainly a matter of expert skill and ingenuity on the part of the experimenter. (6) Ordinarily musical education is not effective as a means of improving pitch discrimination."[1]

Sense of pitch instinctive. This absence of improvement with practice in ordinary musical education finds explanation from two points of view. In the first place, hearing of pitch is an instinctive capacity which comes into function very early in infancy and develops quickly in the individual on account of the biological function that it has served and now serves. It is well known that basic powers which are instinctive develop so quickly in the individual that this has often been taken as evidence of their being inherited as such.

Develops early in speech and other vocal expressions. Furthermore, the sense of pitch develops in speech and, as children ordinarily have more exercise in expression through speech than through music, the development of this mental capacity takes place through speech rather than through

[1] "The Measurement of Pitch Discrimination," *Psychol. Monog.*, No. 53.

music. Observe with what graceful musical inflection of pitch the little child of five says, "Peek-a-boo," "I see you," "Yes, father, please do." All this wonderful control of pitch in the speaking voice is of course conditioned upon the presence of capacity to hear pitch whether it is ever thought of consciously as such or not.

Ordinarily before music is taught. On the other hand, much of our musical instruction, both vocal and instrumental, does not furnish effective training and refinement of pitch hearing, as we ordinarily deal with the large intervals and, in the piano and similar instruments, with mechanically fixed intervals. Training with voice or violin may be more specific in pitch training than is training in speech; but, at any rate, pitch discrimination is usually developed to its full capacity before formal musical instruction is begun. The training in agreeableness of speech may furnish more refinement of the sense of pitch than instruction in the piano does.

Bearing on training. What about the nature and need of training then in the face of this scientific fact of the fixity of pitch discrimination? Two things are certain: first, knowledge of the actual, natural capacity of a child in this respect should be taken into account in determining the kind and extent of musical training the child should attempt; and, second, other things being equal, the better the ear, the more profitable and the larger the range of possibility in musical achievement, in so far as the appreciation of pitch is concerned. The training is a training of the mind in the power to use an instrument of fairly fixed capacity, that of the pitch-differentiating mechanism of the inner ear.

Slight tendency to give musical education to those who possess good sense of pitch. Another question arises in

this connection: Are the children who, at the present time, get formal training in music those who have a keen sense of pitch? On this issue the evidence, which has been collected from a great variety of sources, is surprisingly negative. Thus, a correlation of the sense of pitch and the amount of training for the same five hundred and sixty-three children as in Table II, by the same method as in that table, gave a result as nearly negative as that for brightness, in Table II. That is, the tendency to give the musical education to those children who have a keen sense of pitch is very slight. We are almost as likely to find the fine ear among those who have had no training as among those who have had training. Although absence of concrete information is the main cause, this situation is undoubtedly due in large part to the prevailing false theory among music teachers in regard to what training can accomplish in this respect.

We must not jump at the conclusion that this absence of correlation is all wrong; for the sense of pitch is only one of the many factors involved in musical talent, and selection for training should be based upon knowledge of all the factors as viewed in a composite whole. A large majority of normal persons have a sufficiently good sense of pitch to justify some degree of musical education.

Superiority in sense of pitch related to superiority in singing. But what is the result if we compare ability in pitch discrimination with some spontaneous evidence of musical interest and achievement? The teachers' rating of children in singing in school is a typical illustration. The children referred to above were classified by the teachers as to ability in singing, as for brightness, into the five grades: A (10 per cent), B (20 per cent), C (40 per cent), D (20

per cent), and E (10 per cent). Table III tells the story: there is a considerable agreement.

We should of course not look for complete agreement, for pitch discrimination is only one of the very many conditions of success in singing; a person with a poor ear may have a beautiful voice or other mark of good singing; and the best ear may be associated with a helpless voice. Furthermore the ratings of the teachers are here, as elsewhere, open to certain sources of error.

Table III. Correlation of the Sense of Pitch with Teachers' Estimate of Ability in Singing

Pitch

	% Rank	A 100–93	B 93–79	C 79–55	D 55–13	E 13–1
Singing	A	**(10)** *1* 3.4	*2* 2.3	*4* 3.7	*2* 1.6	*1* 0
Singing	B	*2* 2.3	**(20)** *4* 5.5	*8* 9.1	*4* 2.3	*2* 1.1
Singing	C	*4* 2.8	*8* 77.5	**(40)** *16* 16.1	*8* 6.2	*4* 2.8
Singing	D	*2* 1.1	*4* 3.0	*8* 6.6	**(20)** *4* 6.4	*2* 3.0
Singing	E	*1* .3	*2* 1.6	*4* 4.4	*2* 3.4	**(10)** *1* 3.0

The black-faced figures show what the distribution should be if pitch discrimination were exactly proportional to "singing."

Italics show what the discrimination should be if there were no agreement between these factors.

Significance for training. We may, therefore, sum up our statement of the effect of training by saying that the physiological limit for pitch is set early in infancy, and that the mental capacity for using the sense to this limit develops very early, chiefly through speech, but also through other

forms of intonation in play and singing. As was found for age, if the child is bright so that he can understand what is meant by pitch at the age of, say, five to ten, before musical education has been begun, he will be able to make as good a record as he will after an extensive musical education and arrival at maturity. But training in the use of the sense of pitch offers unlimited avenues for aggression and mastery of new situations which represent the accumulation of information and the development of skills in the art of hearing the intricacies of music as well as the exquisite pitch complexes in nature.

XIII. Capacity Elemental

We call the test of a mental capacity elemental when it is so simple and natural that the resulting record does not vary with training, intelligence, or age after the child is intelligent enough to observe. We are now in a position to see that pitch discrimination is an elemental capacity in this sense. This is of great practical significance in view of the fact that it enables us to make this test early in childhood before musical education is obtained and, within reasonable limits, on persons who differ greatly in the degree of general information, intelligence, and training. It must be remembered, however, that the test is elemental only in so far as we deal with the proximate physiological threshold. In this characteristic of being elemental it differs radically from tests of the ability to hear overtones, timbre, and other complexes of musical pitch.

XIV. Basic Nature of the Test

This test is basic in the sense that many other aspects of musical capacity rest upon the capacity here measured.

Thus, tonal memory, tonal imagery, the perception of timbre, singing and playing in true pitch, and to a certain extent, the perception of harmony, and the objective response in pitch are qualified by any limitation that may be set in pitch discrimination. The evidences for these facts are the result of both theoretical analysis and cumulative experimental record. If the pitch discrimination is poor, we can predict, at least, a corresponding inferiority in the derived factors. On the other hand, excellence of pitch discrimination does not necessarily insure excellence in these factors, since it is only one element in them.

XV. Norms for Vocational Guidance

Norms for interpretation. In all measurements of talent we must first develop the technique and means of measurement, and establish norms of fact such as the distribution curves, Figures 6 and 7. But this is only halfway, for it remains to establish norms for the interpretation of the significance of these measures. This must necessarily proceed empirically in so far as it involves very complex problems which it will take many years of experience and technical skill to evaluate. In so far as this particular capacity is concerned, it is perhaps fairly safe to apply the following principles which the author proposed in 1901,[1] and does not see any reason to modify in the light of extensive experiments since that time. They are as follows (assuming that the test is reliable and represents the proximate physiological threshold):

Below 3 d. v.: May become a musician.

3–8 d. v.: Should have a plain musical education.

[1] "Suggestions for Tests on School Children," *Educ. Rev.*, 1901, XXII.

9–17 d. v.: Should have a plain education in music only if special inclination for some kind of music is shown.

18 d. v. and above: Should have nothing to do with music.

More than pitch in music. It will be observed here that the first group, those who may become musicians, includes more than half of all normal persons. That is, a person may gain the highest proficiency in some kind of music without ranking very high in pitch discrimination. But achievement in certain kinds of music depends upon the degree of excellence of the ear. Thus, the violin demands a far finer ear than a horn, and a horn a finer ear than a piano. It is very interesting to study objectively the practical turn of activity on the part of successful musicians with reference to this limit of pitch hearing.

An inferior ear for pitch may serve well for music in which rhythm is the dominating feature. One need not necessarily have a fine ear to appreciate melody and harmony as rendered by others or by keyed instruments. A certain well-known singer has a pitch discrimination of 6 d. v., which is very poor for a musician, but she sings "songs" in which her exquisite tone quality, graceful rhythm, and beautiful figure and expression of face cover the defect, and one feels that she is taking liberties with pitch for intentional effect. She glides in graceful flights of pitch without sustaining any fixed level in particular.

A more general standard. A more flexible way of stating rules for guidance would be to say that, other things being equal, and due allowance having been made for this record in relation to all other records of musical capacity, the advice should be as follows:

Best 10 per cent: stimulate enthusiastically.

Next 20 per cent: encourage freely.

Next 40 per cent: encourage.
Next 20 per cent: question.
Next 10 per cent: discourage.

Further discussion of the matter must be reserved until we come to consider guidance in general, remembering that one should never guide on the information of a single factor by itself but must always take the whole into account.

XVI. Heredity

Inheritance of sense of pitch not proved. As was pointed out in the general discussion of inheritance of musical talent, the massive literature on that subject is very crude in the light of the new possibilities of scientific isolation and measurement of specific factors. If asked whether the specific capacity of pitch discrimination as a factor in musical talent is inherited, we can answer in general on the basis of the old literature that it is. But the only experimental evidence available on the inheritance of the sense of pitch is negative. Smith measured accurately the pitch discrimination of 1980 school children and worked out the correlations for this capacity (1) between brothers and sisters, and (2) between members of the same family and members of different families. To quote his conclusions: "The coefficient of correlation between brothers and sisters on the basis of pitch discrimination is not higher than between other children." [1]

This finding, which, so far as the writer knows, is the only available specific evidence on the inheritance of pitch discrimination, seems rather surprising and should be considered as tentative, because, while the measurement of pitch discrimination can be vouched for, the treatment of

[1] *Op. cit.*

relationships under these circumstances requires a more favorable selection of groups in large numbers.

Many musical capacities unrelated. The more recent studies of inheritance would make it reasonable to suppose that there are several factors in musical talent, of which pitch discrimination is one, that should be inherited according to the Mendelian laws. On the other hand, there is no reason for assuming that there is any necessary relationship between, for example, sense of pitch and sense of time. Organically, these are as unrelated as height in stature and ability in mathematics. When we realize further that memory, imagination, thought, feeling, and action as employed in music, are quite specific powers which may vary quite independently of one another, the situation grows complex.

Scientific study of musical inheritance. The comparatively large, though scattered, literature on the inheritance of musical genius is of little value because it does not deal with tangible fact. It merely essays to determine whether or not the ancestors of a given musician were or were not musical, on the whole. The scientific study of musical inheritance must begin with questions like these: How far can we trace in a given lineage a marked development (or absence) of the sense of pitch; the sense of rhythm; the sense of intensity; auditory imagery, creative imagination, musical memory; absolute pitch; musical intellect; musical feeling; execution of pitch; execution of time; execution of expression? Such distinctions are, of course, involved in embryo when biographers attempt to show that a given trait of musical power, such as the logically creative, the romantic, or the blindly impulsive, is inherited, but from that point of view we have no statistics.

The analysis of musical talent into isolable factors, and the development of the technique of measurement compel us to make a fresh start in the study of inheritance of musical genius.

One factor at a time. Pitch discrimination may now be measured quantitatively from generation to generation in musical or unmusical families; its relation to other factors

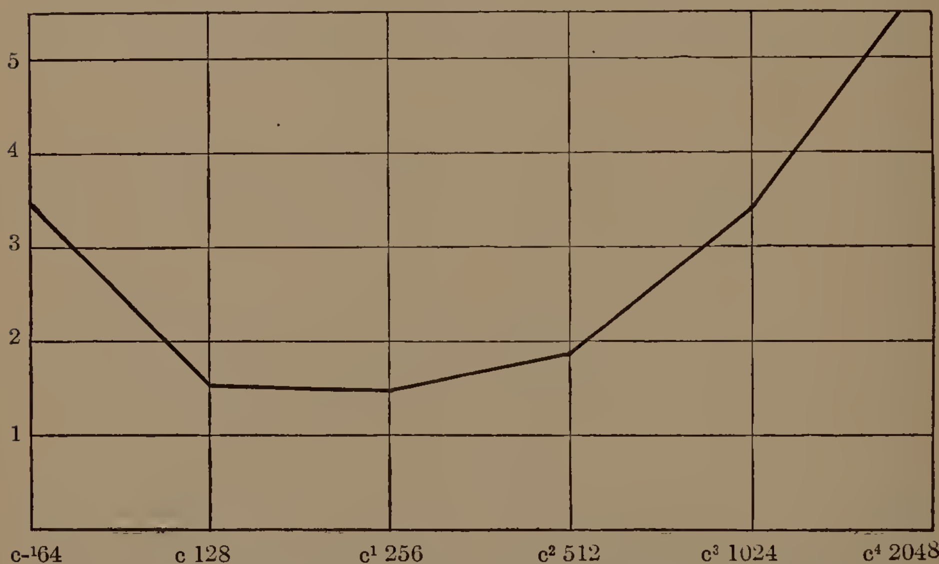


Fig. 8. — (Vance[1]). Variation of Pitch Discrimination within the Tonal Range.

This figure is expressed in absolute terms, *i.e.*, the pitch discrimination for each pitch in terms of vibrations. In Figure 9 the same data are expressed in relative terms, *i.e.*, in terms of fraction of a tone. In Figure 8 the numbers at the left denote vibrations; in Figure 9, tenths of a tone. In both charts the pitch level is given at the bottom.

in musical talent may be submitted to experimental tests by the application of the technique and theory of interpretation now coming into biology, particularly genetics. The way is clear and there is promise of results of value, not only to music but, on account of the tangibility of musical talent, through music to genetic theory in general.

[1] Thomas F. Vance, "Variation in Pitch Discrimination within the Tonal Range," Univ. of Iowa, Stud. in Psychol., 1914, VI.

A scientific attitude. Aside from scientific measurement, the emergence of a concrete analysis, such as that here attempted, should do much to give critics and biographers a point of view which will enable them to observe and record musical traits with such discrimination and in such detail as to throw much light on the problem of inheritance of musical talent.

XVII. Tonal Range

Relative discrimination at different pitch levels. Figure 8 shows the relative keenness of the sense of pitch for the range of pitch most used in music. These curves are based upon the average for fifty-five observers selected without reference to musical ability. The measurements were made by the latest refinements of method and with great care.

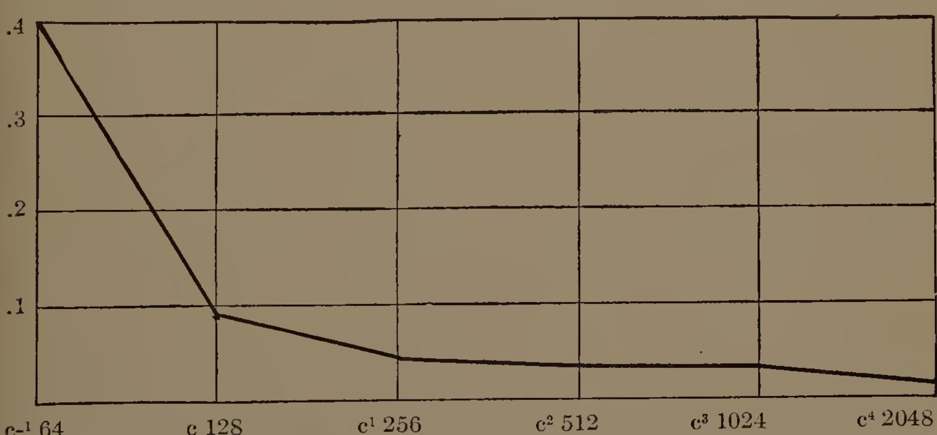


Fig. 9. — Variation of Pitch Discrimination in Terms of Fractional Parts of a Tone.

We may divide the curve roughly into three sections: (1) one octave, 64 to 128; (2) two octaves, 128 to 512; and (3) two octaves, 512 to 2048 d. v. In the first section the curve drops rapidly, indicating greater keenness with the rise of pitch; in the second section it remains comparatively level, indicating almost equal keenness throughout these

two octaves; while, in the third section, there is a rapid rise, indicating a corresponding loss of keenness with rising pitch. But these statements have been made in terms of vibrations, that is, absolute terms. If, however, we express the same data in terms of fractional part of a tone, the curve will take the form of Figure 9, in which we see that keenness in the sense of pitch increases rapidly within the first octave and remains approximately constant for the highest two octaves.

Further interpretation. It requires some effort to see the relations thus expressed from the two points of view in these figures, but it is worth the effort. The application is clear: if we can hear a difference in pitch 1.5 d. v., at c, 128 d. v., then we can hear a difference of about 1.5 d. v. an octave higher, c′ 256 d. v.; but, in relative terms, this means that we hear the lower tone with only half the precision that we hear the upper, because 1.5 d. v. at the lower note denotes $\frac{1}{12}$ of a tone, while 1.5 d. v. at the higher note equals $\frac{1}{24}$ of a tone. Or, since the general trend of the curve is the same for men as for women, when, conventionally, a man and a woman sing the same note, the woman sings an octave higher than the man, and we can detect an error in the woman's singing with twice the precision that we can detect it in the man's. We shall see later in the discussion of the singing of pitch that the woman also sings the note with double the precision that the man can attain when she sings an octave higher than he does. Vance found that, on the whole, pitch discrimination within the tonal range shows the same character for men and women, that is, although they sing differently, they hear alike.

The record of Stumpf. The most exact record we have on a highly trained musician and reliable observer is per-

haps that made by Meyer[1] on Stumpf. He found that in the range from 100 to 1200 d. v. a difference of approximately one third of a vibration could be perceived; that is, within this limited range the absolute differences of pitch discrimination tended to remain constant, and the relative discrimination doubled for each octave.

Table IV. The Pitch Discrimination of Highly Trained Musicians

No.	d^{-1}	c^0	c^1	a^1	a^2	a^3	g^4	c^5	g^5	c^6	g^6
1	0.07			0.1			13	60			
2	0.04	0.2	0.6	0.8	1.3		5	22	130	830	
3	0.13	0.2	0.2	0.2	0.4	1.8	69				
4	0.08	0.13		0.3	0.7		15	41	470	630	2500
5	0.25	0.3		0.5			16	44	195	830	5830
6	0.07	0.13	0.21	0.3	0.5	1.0	2	8	44	265	
7	0.33	0.3	0.4	0.6	1.3	4.1	21	60	260		
8	0.17	0.2	0.3	0.5	1.1	2.6	7	10	39	43	138
9	0.53	0.27	0.16	0.4			19	28			
10	0.10	0.2	0.5	1.1	2.8	7.6	26	110			
11	0.17	0.3	0.5	0.8	1.4	2.7	5	20	102	200	525
12	0.08	0.13	0.20	0.2	0.5	1.3	3	4	113		
13	1.00	1.0	0.9	0.9	1.0	1.4	2	6	56	93	252
14	1.2	0.9	0.4	0.2	0.5	1.4	4	16	413		
15	0.5	0.4		1.1	2.0		16	40	351	830	
16	0.9	0.9		0.9	1.1		5	12	84	590	

Records of trained musicians. The best collection of measurements on the pitch discrimination of highly trained musicians is that of Stücker[2] who examined members of the Royal Opera in Vienna, and other highly trained persons. His most significant records are reproduced here as Table IV. Examination of this table shows the great diversity of capacity of different musicians. He gives a similar

[1] Max Meyer, *Ztschr. f. Psychol.*, 1898, XVI.
[2] N. Stücker, *Ztschr. f. Sinnesphysiol.*, 1908, XLII.

table for great singers. Numbers 1–8 were composers and conductors, 9–11 pianists, 12–13 violinists, 14–17 oboe players. Numbers 1, 2, 3, 4, and 12 were prominent in the direction of the Royal Opera. The figures in the table represent the least perceptible pitch differences, in terms of vibrations. Recent criticism of methods has demonstrated that some of the extremely fine records given in this table are unreliable: we have no unmistakable evidence that any human ear can hear any difference finer than one tenth of a vibration, or even as fine as that.

Difference due to talent, not training. As a rule the records in this table are very much finer than those given for unselected observers. With unselected observers, Stücker finds about the same distribution as is given by Vance. This difference between musicians and others is not because the musical are trained, but because they are musical; that is to say, persons who have been born with a high order of the sense of pitch have survived in music and may have had an opportunity to distinguish themselves in this respect.

Certain interesting phenomena of pitch defects which are due to partial loss of hearing will be discussed in the chapter on intensity. Among these are the phenomena of tonal gaps and tonal islands.

XVIII. Pitch Difference in the Two Ears

Ears tuned to different pitch. There are, of course, numerous pathological conditions and gradual transitions of these into the so-called normal condition in which the pitch mechanism in one ear is entirely destroyed, or may be in any stage of impairment ranging from normal condition to complete disability. If the other ear be normal, this

defect will perhaps not be observed. It is generally stated in the textbooks that frequently the two ears seem to be tuned to a different pitch; for example, so that a tone of, say, 435 d. v. in one ear may sound of the same pitch as a tone of the pitch of 430 d. v. in the other ear. This matter has not yet been treated adequately by experiment. It presents an important field for further investigation because it would seem reasonable to suppose that if the pitch-differentiating mechanism in one ear is entirely independent of that in the other, there might be physical conditions which could develop a permanent difference in the two ears and develop acute changes which would cause temporary differences in the registering of pitch.

May have theoretical bearing. No exact measurements have been made or statistics collected to show to what extent the two ears tend to differ in pitch discrimination. Theoretically, it would seem probable that there should be very large differences in the power of discrimination of the two ears, and since we do not ordinarily isolate one ear from the other, either in hearing music or in ordinary experiments in the hearing of tones, such differences might pass undetected. Careful study of that problem might, however, throw important light on the pitch-differentiating mechanism in the ear.

XIX. Illusions of Pitch

Normal illusions. Like all our other sensory experiences, pitch is subject to a great variety of so-called normal illusions; *i.e.*, illusions which are predictable, relatively constant, and traceable to specific factors in the sensory mechanism, subjective or objective. One of the most bewildering experiences of a trained observer is to find that he is subject to very strong illusions of difference.

Must be eliminated in measurement. Similar to this are the illusions due to the differences in intensity, timbre, pitch level, location, etc., of the tones. All such errors must be eliminated. It would be no test at all merely to ask the observer if he heard a difference, as the early experimenters did; he must be required also to give the direction. By virtue of the illusions we often tend to hear two tones of the same pitch as different and sometimes feel a higher degree of certainty in a judgment which is wrong.

Very much depends upon the direction of expectant attention. Listening to two tones physically of the same pitch one can make either tone seem higher or lower at will. This introduces a very serious difficulty in the experiment. It is exceedingly difficult to keep the observer from directing his expectant attention in favor of one tone or the other. Great ingenuity and watchfulness on the part of the experimenter is necessary in order to keep the observer as neutral as possible.

May be measured. Many of these illusions of pitch have been identified, isolated, measured, and expressed in terms of mental law. Among these is the illusion of anticipation, or expectant attention. If one consciously or unconsciously anticipates that the second of two tones in a small interval is to be the higher and it really is the higher, the difference will seem greater than it really is; but if, on the other hand, it is really lower, there are two possibilities: if it is relatively a little lower, it will still be heard as higher; whereas, if it is distinctly lower, it will be heard as lower, and the interval will be overestimated.

XX. The Sense of Pitch in Animals

Early experiments. Much interest has been aroused in recent years in the investigation of the tonal hearing of animals. Earlier experimenters rejoiced in being able to demonstrate that it was possible to measure the tonal hearing of various animals, but a more careful critique of these methods tends to demonstrate that the response was probably not to the sounds used but rather to some other activity on the part of the experimenter who was present in the room. On the other hand, it was a matter of everyday observation that animals respond to sounds and that they seem to recognize differences in pitch; and the argument has seemed plausible that, since animals are capable of producing sounds of a great range and striking characteristics of pitch, they should be able to appreciate these quite as it is believed that animals appreciate decorative coloring.

Method of conditional reflex. The method of the "conditioned reflexes" strikes the musician as weird; but the fact is, it works. For example, the animal is trained to respond to a certain tone and be rewarded by food, and he learns not to respond to other tones which do not bring food, but punishment. A tone of, for example, 256 d. v. is sounded and learned as a signal for the receiving of food and one or more other tones differing in pitch are sounded under similar conditions except that they are not associated with food. The theory is that, if a dog hears the differences in pitch, he will learn when to get his food and when to avoid punishment by recognizing the proper signal.

Higher animals have good sense of pitch. By such methods results have been obtained on higher animals, particularly the dog and the monkey, showing that they

may have a good pitch discrimination and that it can be measured. In a short time we shall undoubtedly have interesting and accurate data on the pitch discrimination of different types of animals under conditions which may be verified under exactly the same control with human beings and thus compared with conscious reaction.

CHAPTER III

THE SENSE OF INTENSITY

Hearing ability and intensity discrimination. There are two fundamental aspects of the hearing of intensity: first, the hearing ability, or acuity, which is measured in terms of the faintest audible sound; and, second, the ability to hear differences in the intensity of sounds, which is measured in terms of the least perceptible difference and is usually called intensity discrimination.

I. The Physiological Basis

The intensity mechanism. We found the pitch-differentiating mechanism limited to a harp structure, enormously intricate and yet one continuous gamut. But, when we come to the physiological basis of intensity, the situation grows even more complicated; for, not only does the intensity of a sound depend upon each and every part of this harp structure, but it depends also upon each and every part of the conducting mechanism from the external ear to the final discharge in the auditory cells, as well as upon the nerve and the complicated brain connections.

Explanation of Figure 1. The mechanism in the ear for the transmission of intensity differences in sound may be represented in a very schematic way in Figure 1. This figure should be studied with the aid of a good textbook on

the anatomy of the ear. *A* represents a tuning fork, vibrating in front of the external ear, *B*. The amplitude of the vibration determines the loudness of the sound at its source. The vibrations are transmitted through *B* and taken up by *C*, the tympanic membrane. *C, D, E, F* represent the chain of three bones in the middle ear which constitute a compound lever; this does in a small space what a simple long lever, *C E*, would do when acting in the fulcrum *D*. It reduces the amplitude of vibration and increases its force at *E* because the fulcrum is near *E*. *F* is the stirrup which acts as a plunger into the bony labyrinth, *G*, of the inner ear, in which the liquid (perilymph) is caused to vibrate under the forced vibration of the stirrup *F*. *M* is a compensating

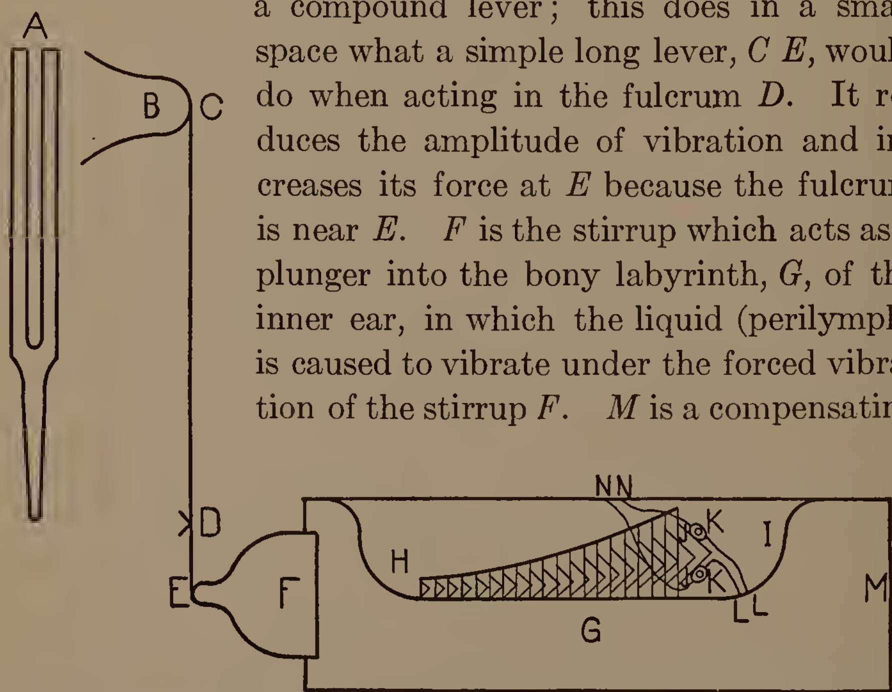


Fig. 1. — A Schematic Representation of the Structures in the Ear for the Registering of Intensity of Sound.

membrane (the round window) which bulges out and retracts for every vibration of the liquid in *G*. *I* is an inner tube (membranous) in which the liquid (endolymph) vibrates transversely under the impulse of the lengthwise oscillation of the perilymph. *H* represents the harp structure, which, with all its superstructure, floats in the liquid within the membranous tube, *I*. *J* represents a trestlework acting as a sounding board (the rods of Corti), one

such standing on each of the thousands of fibers. *K* is a nerve cell which lies in such a position against the trestle-work that it can be so violently shaken by the vibration as to cause a chemical change. *L* is a hair which projects from the cell and acts like a lever, mechanically aiding in the shaking of the cell. *N* is a nerve fiber which conducts the nerve impulse from a particular cell toward the brain.

Purpose of the figure. Complicated as this is, it is vastly simplified from the actual facts as revealed by the microscope. The purpose of the illustration is to show that the keenness in the perception of differences in the intensity of sound depends upon the faithfulness with which the strength of the nerve impulse going out over *N* corresponds to the strength of vibration of the tuning fork, *A*, and that this mechanism is extremely complex and, therefore, subject to many sources of defect. It would be marvelous if any two human ears should be equally sensitive. Indeed, one of the wonders of nature is that we are so nearly alike and so reliably sensitive as we are. The ear as an instrument for transmitting and registering the amplitude of sound waves faithfully and with fine differentiation is subject to an enormous number of disturbances which may modify the sensitiveness to sound, the sensitiveness to the character of sound, and the sensitiveness to differences in the loudness of sound.

Nature of impediments. The hearing of loudness of a sound may be modified physically by disturbances in the tympanic membrane, the bones of the middle ear, the tube-linings, the cavities surrounding the middle ear, and all the parts of the labyrinth accessory to the organ of Corti. The disturbance in each of these places may be of various kinds. It may be a clot of wax on the outer surface of the

tympanic membrane; it may be a ten-fold thickening of the footplate of the stirrup; it may be a calcifying process on any of the movable parts; it may be a softening process in any of the parts which transmit waves under tension; it may be a malformation in the structure of any of these accessory parts; it may be inflammation of the membrane in or around these accessory parts. Indeed, the location of trouble may be in the nerve itself beyond the ear, or in any part of the basal ganglia of the brain, from the medulla upward to the cortex. Some of these disturbances may be hereditary; some may be due to injury; others may be the result of disease, such as scarlet fever, measles, influenza, pneumonia, typhoid fever, smallpox, whooping cough, tumors, blood clots, bone fragments due to breaks, or rupture of the membrane. Others may be due to temporary inflammation or suppuration, or stoppage of air passages, filling of cavities, blood pressure, etc.

Significance of kind of impediment. The kind of difficulty which may appear in the sense of intensity depends upon the location and extent of the obstruction. Thus, for example, if the disturbance is in the middle ear, there is ordinarily a loss of hearing for low tones, whereas if the disturbance is in the inner ear, the highest tones are the first to be lost; so that we find, not only a flat "hardness of hearing" varying in degrees from normal hearing to deafness, but also a variation in hearing ability for different pitches, timbre, or tone quality both in music and in speech.

Vocational significance. For an effective knowledge about these conditions, one must turn to the textbooks on otology and particularly the most recent research monographs in this branch of medicine. But, for our present purpose in the psychology of musical talent, it is only essen-

tial that we shall realize the concreteness of the physical fact that keenness of hearing depends upon the fitness and normality in the transmitting and converting mechanism of the ear and its accessories, and that there are physical reasons for large and significant differences in this capacity. It is not for us to diagnose the location of the trouble or to go into detail about psychological phenomena which depend upon endless varieties of conditions in the ear. Let us simply, frankly, and fairly face this fact, that the sensitiveness to sound and sensitiveness to the difference in intensity of sound, or loudness, vary within a very large range in so-called normal hearing. We may then seek to learn something about the bearing of this upon musical talent.

Effect on overtones. For the purpose of guidance in music we are concerned, not so much with the mere difficulty in hearing of sounds as with the fact that to the person who has a defective ear for intensity, music does not sound the same as to the normal person. What may seem a delicately faint sound to him may be to the normal ear a comparatively loud one. Distinctions in intensity which are of the utmost importance for the control of musical expression may be lost to him, because radical changes (defects) in tone quality may result from defective sensitiveness to different levels of overtones.

II. Tonal Gaps and Tonal Islands

Nature of gaps and islands. The pitch discrimination of a student was measured at the level of a′, 435 d. v., in the laboratory and she proved quite helpless, being unable to detect differences of a half tone or even a whole tone at that level. As she thought herself capable of appreciating music, she was asked to return and be tested for other ranges,

and it was found that she had exceedingly fine sensitiveness to pitch except for about ninety vibrations about a′. She seemed insensitive to pitch differences, even by the keys of the piano, for a′ and a′ᵇ; although she heard the tones, she could not distinguish one from the other.

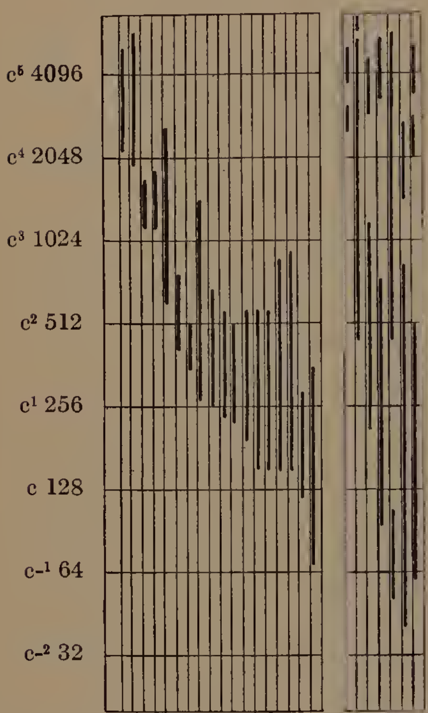


Fig. 2. — (After Bezold[1]). Tonal Islands and Tonal Gaps.

The first eighteen represent islands; the last seven, islands with gaps. The heavy line shows for each case the register of the tones that can be heard.

Examples. We speak of a tonal gap when there is a defect in tonal hearing which is due to the loss of functioning power of certain segments of the harp structure in the ear. When the range of hearing is reduced at either or both ends to a remnant as small as two octaves, we speak of the remnant as a tonal island. We can picture this to ourselves concretely if we think of the bank of strings in a piano as exposed and a child throwing things in upon them — a marble, a building block, a ball, or even a large box or a pillow. If we strike the keys affected, they will have lost their power to respond in the natural way. Let us carry this analogy into our interpretation of tonal islands and tonal gaps.

“**Patches of hearing.**” Figure 2 shows graphically a group of eighteen tonal islands and seven types of tonal gaps. These cases were all found in an institution for deaf-mutes,

[1] Fr. Bezold, “Textbook of Otology,” E. H. Colegrove Co., Chicago.

who often have what is called a "patch of hearing," usually in the region of the high notes. The point emphasized by this figure is that loss of hearing, when due to injury in the inner ear, may occur independently at any pitch level.

Effect on speech and music. In modern instruction of the deaf, this "patch" is taken advantage of by teaching them to make use of the range of hearing they have. If a person has an island running from b′ to g″, he can learn to hear ordinary speech well, because the most salient characteristics of speech sounds fall within that range; but varied or rich musical tones do not sound to him as they do to a person with normal range, because the high overtones are lost. Ordinary cases of persons "hard of hearing," when analyzed, prove to begin with the loss of certain speech sounds, such as the sibilants, s, z, sh. On the basis of exact analysis of sounds lost, one can diagnose to some degree the exact pitch level of the lesion in the inner ear. The same can be done for the musical sounds.

Limits not always abrupt. In the diagram, the gaps and islands are shown as abrupt breaks, but in fact they should be represented in most cases in terms of the degree of loss of hearing as was illustrated in the case of throwing objects upon the piano strings. Some strings might be entirely broken; others might simply be damped.

Frequency. We have no satisfactory statistics to indicate to what extent tonal gaps occur in so-called normal hearing. A very careful examination of the tonal range of fifty-five university students by Vance[1] revealed no case of complete gap for any one, but demonstrated one case of a relative gap in the region 60–90 d. v., in which the pitch discrimination rose suddenly at 90 d. v. from less than 1

[1] *Op. cit.*

to about 8 d. v. This seemed to affect pitch only, as there was no loss in intensity or richness of the tones in that gap. The subject was no more aware of this defect through hearing than the color-blind can perceive his color blindness.

Some factors involved. The whole problem of how these gaps occur in one ear and not in the other, and of how the good ear "covers up" the defect in the other ear remains to be investigated. We shall probably find that gaps in one ear are common, but unless the other ear is similarly affected the defect will not be noticed. The accurate knowledge of these conditions involves measurement of, first, sensitiveness to tones or acuity of hearing; second, the pitch discrimination; and, third, the intensity discrimination for each and every level of pitch within the tonal range.

III. Acuity of Hearing

Physiological and mental aspects. There are two aspects of acuity of hearing, the physical and the mental. Ordinarily defective acuity is regarded as a measure of the condition of the ear; loss of hearing is attributed to deterioration or to an undeveloped structure of the middle or inner ear. On the other hand, the acuity of hearing reveals the power of application in the perception of sound. A person of low mentality gives unreliable and widely varying responses in a test, and this variability is likely to be an index to the character of the individual in his responses to all sounds; that is, a person may have a keen physical ear but lack the power of concentration and accurate observation. A test of hearing should, therefore, show us two things: the average faintest sound that can be heard, which is in general an indication of the condition of the physical ear; and the variation in a number of records on the same point,

which may be regarded as an index to stability or instability of intellect.

An audiometer. Acuity of hearing, or threshold of hearing, is measured in terms of the faintest sound that can be heard. This may be most conveniently done with an instrument known as an audiometer, Figure 3, which is essentially a telephone connected with a tuning fork and batteries, with devices for standardizing the current and varying the

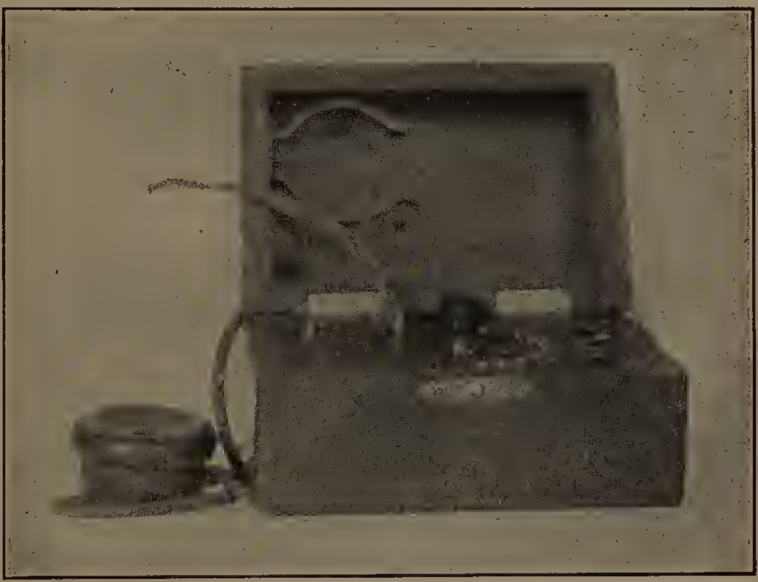


Fig. 3. — An Audiometer.

strength of the current, and therefore the intensity of the sound, in a definite scale of units of sound running, *e.g.*, from 0 to 20. The principle of this test is the same as that employed by the aurist when he uses a watch to find out how far away the ticking can be heard, only far more accurate.

If a single test of hearing is to be made, as in civil service examinations or for pedagogical purposes, a mere click is used instead of a tone. But if we aim to make a thorough

examination for musical purposes, tuning forks of any pitch from fifty to five hundred vibrations are connected with the audiometer, so that the measured sound is a tone of a specific pitch.

Method of measuring. In making a test with the audiometer the observer holds the telephone receiver to the ear to be tested, and the experimenter produces the sound by pressing a button at regular intervals and varies the strength of it by sliding a rider along the audiometer scale, beginning with a sound which is easily heard and continuing downward until the observer ceases to hear the sound. The last sound that was heard is recorded as the threshold of hearing. This test is then repeated a large number of times, and from the record we obtain the average and the mean variation, which is illustrated in Table I for three observers. These records were made with an audiometer in which the "normal" was 15 units in the scale.

TABLE I. DIFFERENCES IN MEAN VARIATIONS

	Observer A		Observer B		Observer C	
	T	*V*	*T*	*V*	*T*	*V*
	15	0	15	0	18	3
	14	1	13	2	11	4
	16	1	18	3	20	5
	15	0	17	2	12	3
	15	0	13	2	9	6
	15	0	12	3	10	5
	16	1	17	2	21	6
	15	0	13	2	9	6
	14	1	18	3	16	1
	15	0	14	1	12	3
Average	15	0.5	15	2	15	4

T, the threshold or faintest sound heard.
V, the deviation of each record from the average of all the records.

Mean variation. The mean variation, it will be observed, is the average deviation of a series of records from the average of that series. The three cases given in Table I are selected to illustrate the significance of difference in mean variation as a measure of reliability. Although all three records have the same average, 15, observer A manifestly has the poorest ear and the best mind in the matter involved. He is accurate, showing but a very slight mean variation, which means that he uses his actual physical capacity to best advantage. Observer C undoubtedly has the keenest ear but the poorest mind in this respect. He is very erratic, as is shown by the large mean variation, and this large variability prevents him from getting as low an average record as his actual psychophysic capacity warrants. Observer B occupies a middle ground in both respects.

In interpreting these figures the threshold, representing acuity of hearing, should, therefore, always be taken with its mean variation; because, as is shown here, the actual threshold is probably lower than the average given, somewhat in proportion to the magnitude of the mean variation.

A personal equation. On the other hand, the mean variation is an important measure in itself, namely, a measure of the personal equation as to uniformity and reliability in hearing in general. It is a matter of great consequence in music whether a pupil's mind is of the A type, the B type, or the C type. This personal trait, or equation, may be measured in any of the quantitative tests but need not be repeated in every test, because it represents a general trait of mind in the measurement of talent. A mind that is erratic in listening to a faint tone is quite certain to be equally erratic in observing fine distinctions of any kind in hearing.

Instruments not always necessary. For the purpose of

rating musical talent, defects in acuity of hearing can ordinarily be detected without any instruments because they appear in ordinary conversation. If a person's defect is not sufficient to be traced in conversation, it should not be regarded as a serious obstacle in music.

In the medical clinics and in the public school where tests of hearing are made, they generally use what is known as the whisper test, naturally of course very crude and yet valuable. We shall not here discuss the details of norms and technique as they must vary for the various instruments and methods.[1]

IV. Acuity of Hearing throughout the Tonal Range

The pitch range audiometer. Since the sensitiveness of the ear varies for different pitches, and irregularities of this kind in the form of tonal gaps are much more frequent than is ordinarily supposed, it is important to measure hearing at all pitch levels. Fortunately, an instrument has recently been devised which measures acuity of hearing at each and every pitch level for relatively pure tones, in an extraordinarily simple and quick way. The first model of this instrument is shown in Figure 4a.[2] The tone is produced

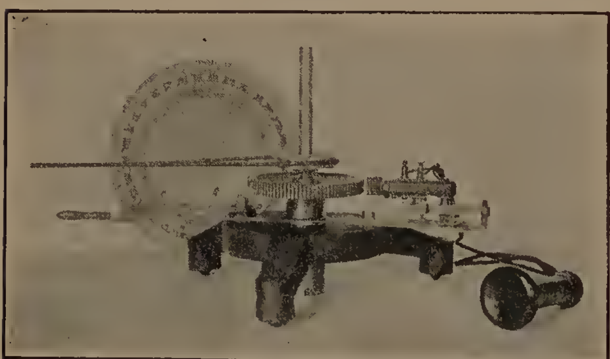


Fig. 4a. — An Early Model of the Pitch Range Audiometer.

[1] A good account is given in Whipple's "Physical and Mental Tests," Warwick and York, Baltimore.

[2] This Pitch Range Audiometer is being developed by Mr. Cordia C. Bunch, and has not yet been technically described.

in a telephone receiver by rotating a cogwheel in front of a magnet. The pitch of the tone depends upon the speed of rotation, which is measured either stroboscopically or by means of a frequency meter. The intensity is varied by moving the magnet to and from the revolving wheel by means of the long lever. In the new models, now in process of construction, certain important modifications have been

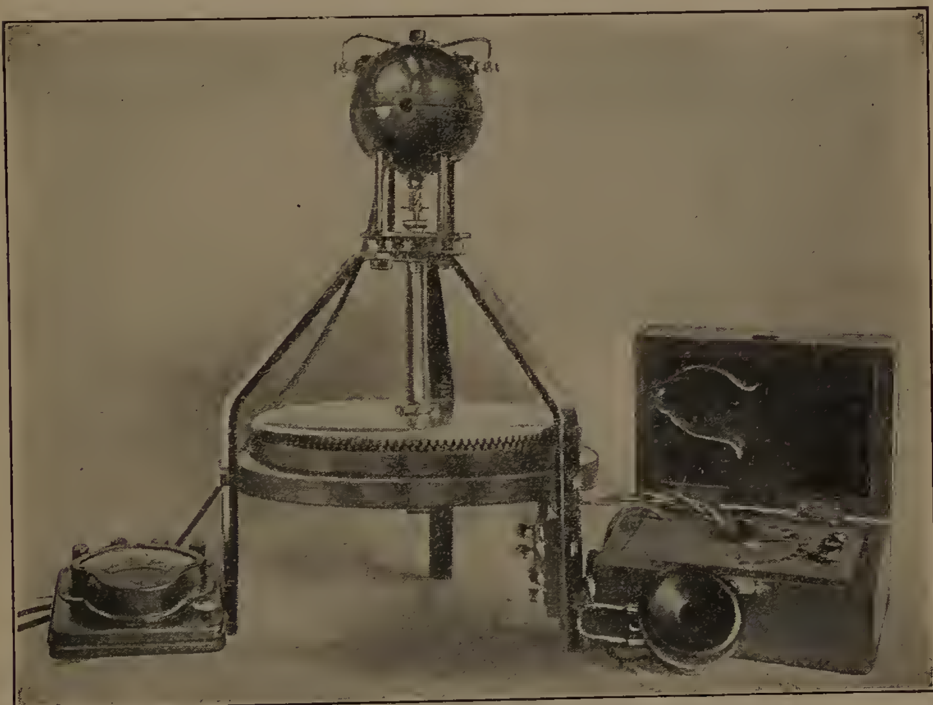


Fig. 4b. — The Latest Model of the Pitch Range Audiometer.

made, but the general principle is the same. By gradually speeding up the motor which drives the wheel, we can raise the tone from the lowest to the highest audible pitch as rapidly as we please. This may be repeated for any desired number of intensities. In this way tonal gaps will be located. In the same manner the acuity at any pitch may be measured by starting with the loudest tone and turning the

magnet lever gradually until the tone at that pitch disappears.

Just before this book went to press, the pitch audiometer had evolved into the form shown as Figure 4b. Here, instead of having one two-pole magnet as in 4a, the lower wheel is built into a magnet with as many poles as there are teeth. The principle of tone production, however, remains the same. For each time that the teeth of the upper wheel coincide with the teeth of the lower wheel, which is stationary, an electric pulsation will be sent into the telephone receiver producing the sound. The pitch, as determined by the speed of revolution, is here measured by means of an electric speedometer which consists essentially of the globe generator seen at the top and is read in terms of the galvanometer at the left. Instead of varying the distance of the magnet, the intensity is here varied by means of a shunt resistance in the audiometer seen at the right.

Figure 5. The result of such measurements may be illustrated as in the charts of Figure 5, which gives the hearing charts of the first four men in the S.A.T.C. who came up to be examined for admission into the radio service. Since these four men were unselected cases, and yet represented persons who were going to depend upon the sensitiveness of their ears in an important way, the differences among them are significant. The pitch levels are indicated roughly in terms of vibration frequency at the base. The intensities are indicated by the letters A, B, C, etc., — the loudest tone, A, being so loud that it was on the verge of being painful to the sensitive ear, and F, so faint that only keen ears could hear it. The ability of a very good ear is represented both in pitch and in intensity by a rectangle. Deviation from the rectangle shows a corresponding defect.

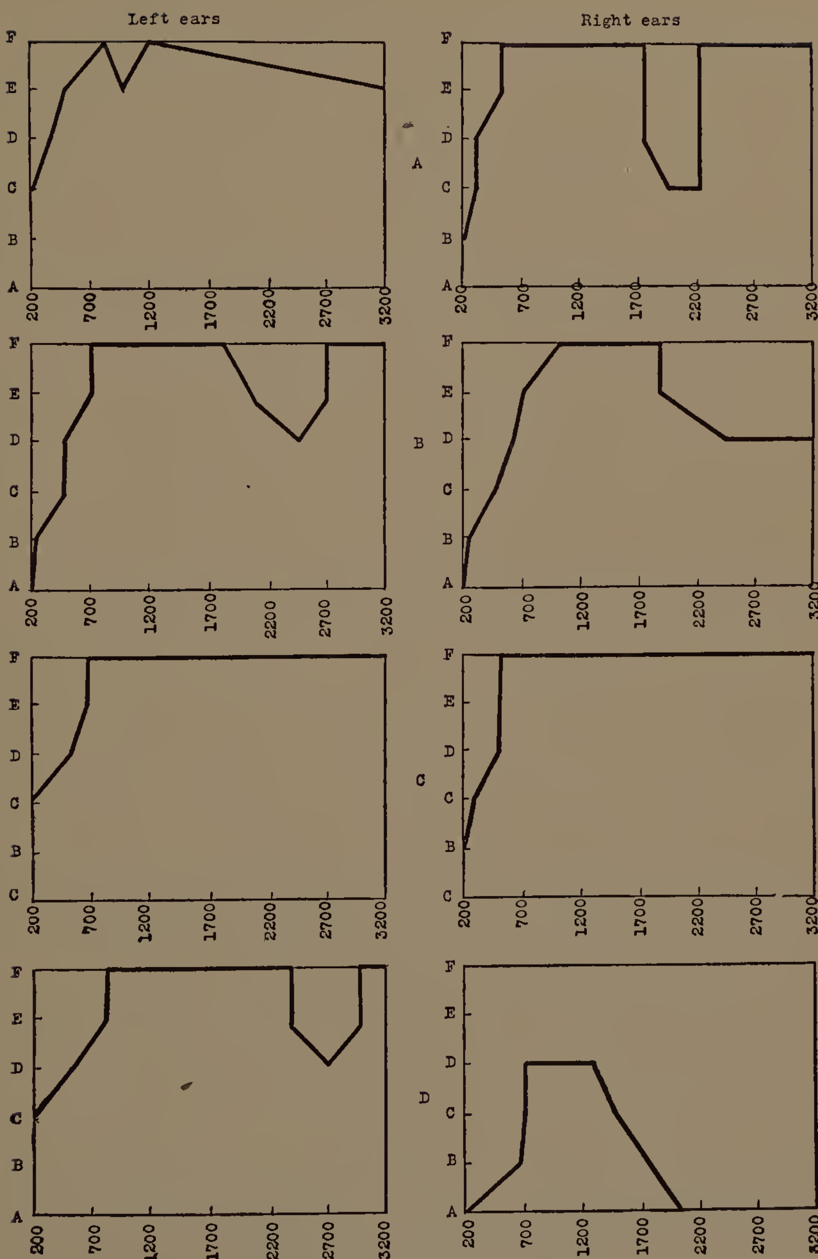


Fig. 5. — Charts of Tonal Hearing.

Uses. The significance for music of such differences is self-evident. We can here speak, in very concrete terms, of what the musician can hear and what he cannot hear in pitch, intensity, and timbre of sounds.

Other uses of this measurement. This instrument has found a most vital place in otology. It has been demonstrated that it is of inestimable value in the diagnosis of hearing troubles. It has also been found that, by making these surveys of children, incipient ear troubles may be discovered before they have become acute, and may, therefore, be warded off. There are also many phases of industry, such as radio work, in which the elimination of those persons who cannot hear essential pitches, may be a means of great saving.

V. Periodicity in Sound

Rhythm in attention to sound. All our mental life works rhythmically, that is, by periodic pulsation of effort or achievement with unnoticed intermittence of blanks. This is most easily observed in an elemental process such as the hearing of faint sounds. To demonstrate it in a simple way, proceed as follows: hold a watch a distance from the ear and then move it toward the ear until you can just hear it; then keep it in this position for two or three minutes and observe that you hear it only intermittently. To indicate this, raise your finger when you hear the sound and lower your finger when you do not hear it. Do not be influenced by any theory, but act with the keenest decision for every second. You will then find that the hearing and silence periods alternate with fair regularity, the periods varying from two to eight or ten seconds in the extreme. This periodicity is primarily a periodicity of attention and reaches out into all our mental processes, being one of

nature's contrivances in the interest of the conserving of nervous energy. In tests of hearing it is evident that this periodicity is a disturbing factor and accounts for a certain part of the mean variation which we find.

VI. The Measurement of Intensity Discrimination

Nature of measurement. Technically, the sense of intensity is measured in terms of the least perceptible difference in the intensity, or loudness, of a standard sound. We speak of it as intensity discrimination. This measurement may be made by determining the smallest number of units of difference on the audiometer, Figure 3, the observer can hear. A record of audiometer sounds for this purpose is now available on phonograph disks adapted for use in group testing.

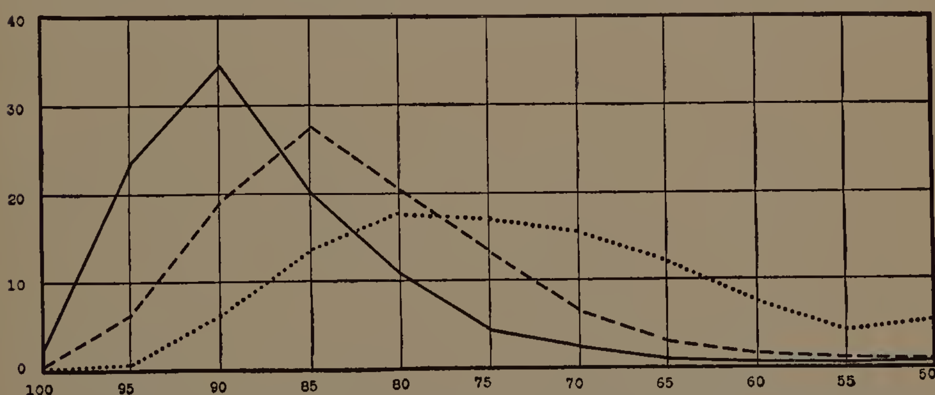


Fig. 6.—Distribution of Capacities in the Sense of Intensity.
Based on the phonograph record Number A7537. Notations the same as in Figure 6, Chapter II.

To make a group test, we ordinarily take at least two hundred trials evenly distributed on five steps, and require the observer to say in each trial whether the second of two tones, the standard and a variable, sounded in chance order, is weaker or stronger than the first. From this we find the percentage of right cases, as above for pitch.

Figures 6 and 7. The distribution of capacities in the sense of intensity is shown in Figure 6 in terms of per cent right. Figure 7 contains norms for the converting of per cent right into rank as in Chapter II. These norms are

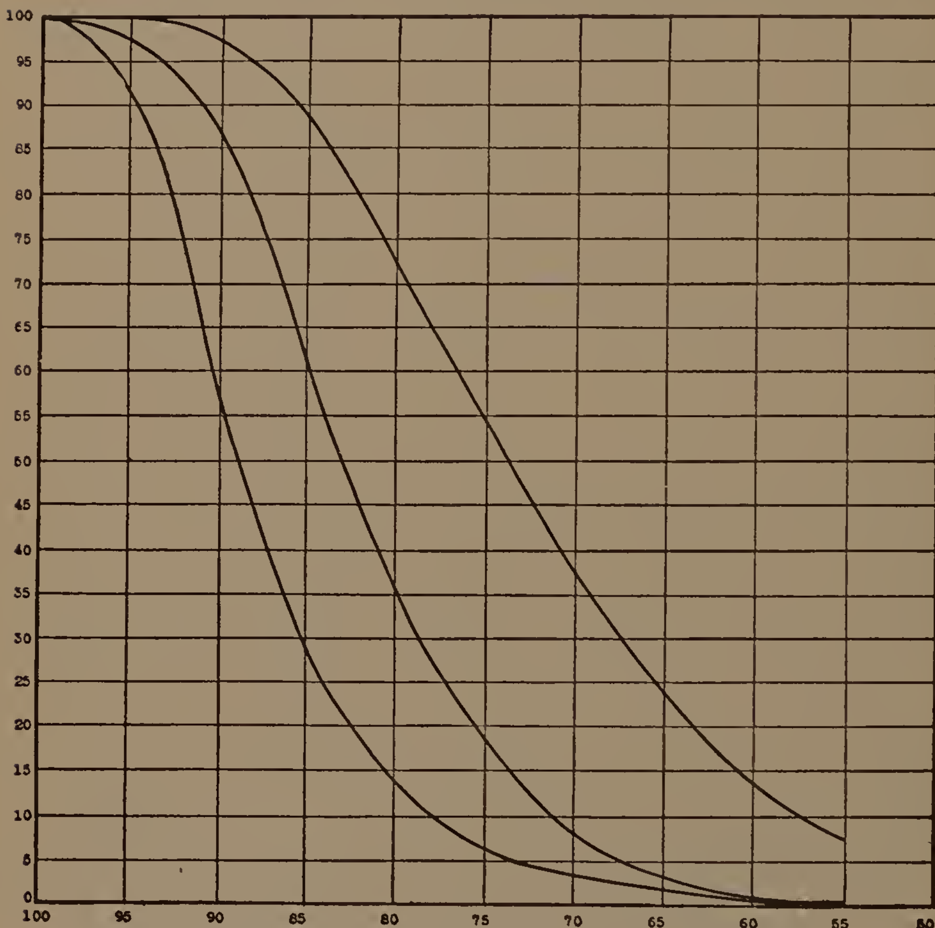


Fig. 7. — Norms for the Converting of Per cent Right into Rank.
Notations same as in Figure 7, Chapter II.

based upon the phonograph records, but these records are so faithful a reproduction of the original audiometer tones that for adults the norm for the records is exactly the same as was found for the audiometer.

Individual measurement. For more exact measurement we take an individual at his particular level of ability, for example, two units of difference as established in a preliminary test, and determine the exact threshold by an intensive series of trials at this point.

VII. Relation to Age

The apparent differences. The norms show that, in group measurements, the older children do slightly better than the younger, and adults do better than the older children. Children are undoubtedly subject to more acute interferences with hearing than are adults; stoppage of the Eustachian tube, and "running" ears are common. On the other hand, permanent injuries are cumulative in all ages. On these points we have no exact information to show whether the situation would tend on the whole to favor children or adults.

Little real difference. If we take children and adults individually and adapt the rigor of the test to the age, the difference which is due to age or mental development in group tests tends to disappear. In other words, if we make measurements for vocational guidance in the schoolrooms or other assemblages of children upon whom a single test is made, we must make an allowance for age, according to norms for different ages; but if we take children individually and make the tests short and maintain a sustained interest, the average child at ten or above will be able to make approximately as good a record as the adult. That is to say, in his natural reactions to the environment, within the realm of his acquaintance with sounds, a child has as keen ear for intensity as the adult. The explanation of this age difference is, therefore, probably to be found essentially in

the presence among young children of a considerable number who have not developed the power of concentration or application to a task in hand.

VIII. Relation to Intelligence

Sense of intensity not closely related to general intelligence. This test has often been used as an intelligence test; but that cannot be justified because we find very little agreement between excellence in this test and brightness of children as ordinarily estimated. This is illustrated in Table II, which is based upon records of five hundred and twenty-two children in the seventh and eighth grades. If

Table II. The Relation of Intensity Discrimination to General Brightness or Intelligence

Intensity

	% Rank	A 100–72	B 72–47	C 47–20	D 20–12	E 12–1
Brightness	A	**(10)** *1* .7	*2* 3.8	*4* 5.0	*2* 1.7	*1* .6
	B	*2* 2.3	**(20)** *4* 4.4	*8* 7.4	*4* 4.0	*2* 1.7
	C	*4* 4.4	*8* 6.1	**(40)** *16* 15.1	*8* 7.4	*4* 3.1
	D	*2* 1.1	*4* 4.0	*8* 7.6	**(20)** *4* 4.8	*2* 2.7
	E	*1* 1.3	*2* 1.7	*4* 4.6	*2* 2.1	**(10)** *1* 1.9

The black-faced figures show what the distribution should be if intensity discrimination were exactly proportional to "brightness."

Italics show what the discrimination should be if there were no agreement between these two factors.

(For further interpretation of the plan of this table, see explanation of Table I, Chapter II.)

there were close agreement, the bright children should tend to make the good records and the dull children the poor records in intensity discrimination, but a perusal of the table shows that there is no clear tendency in this direction.

Nature of variation with intelligence. The chief reason for this absence of correlation lies, of course, in the fact that intensity discrimination rests mainly upon delicacy of structure in the ear, which has no relation to intelligence. There are, however, two other elements in the situation. Ear-mindedness is a type of mind, or a mental set which is especially favorable to the best exercise of the sense of hearing. It is an instinctive responsiveness to sound resulting in efficiency, which is, of course, a sort of brightness. Then, again, a person may be keen in sensory observation and yet not have the qualities which are necessary for success in school studies. Strictly speaking, we are dealing here with two kinds of brightness: the keenness in sense discrimination is actual brightness of a specific type, whereas that measured in ability to carry school work is a sort of *ensemble* of brightness such as excellence in memory, imagination, reasoning, and will power of various kinds.

In normal hearing, intensity discrimination is, therefore, a clear-cut test of intellectual capacity (brightness) for accuracy in the observation of a sound and is the best index to such ability. Other things being equal, the person who has good intensity discrimination makes a reliable observer of sounds, but we must not confuse such specific aptitude with general brightness or intelligence.

IX. Effect of Training

Most people would assume that differences in this capacity would be largely a result of training, but on this point we

have negative results from three independent types of experiments.[1]

Evidence: extended training. Fourteen observers were selected regardless of initial ability and subjected to a prolonged series of specific and intensive practice of from fourteen to thirty periods of one half hour each, and a record was kept of performance from day to day. The general conclusion from this experiment was that systematic practice under the most favorable conditions did not result in a change of the record. On the whole, the achievement of these fourteen observers was practically the same at the end of the practice periods as at the beginning.

Evidence: the case of the blind. It is generally supposed that, since the blind guide themselves by hearing so extensively, they must have more highly developed sensitiveness to sound. To test this we took fifteen students in the School for the Blind who had been blind from early infancy and were normal in other respects, and had acquired skill in various kinds of work and ability to orientate themselves without sight. We compared the achievements of these with the achievements of fifteen seeing high school pupils selected under similar conditions, and the result of this, the most careful test of its kind, was to show that the average for fifteen blind and fifteen seeing persons is approximately the same. This means that the intensified training which the blind have had since childhood has not tended on the whole to make them keener in this specific sensory capacity.

[1] Seashore and Ling, "The Comparative Sensitiveness of Blind and Seeing," Univ. of Iowa, Stud. in Psychol., 1918, VIII; Seashore and Tan, "The Elemental Character of Sensory Discrimination," *ibid.*; Seashore, "Elemental Tests," *Jour. of Ed. Psychol.*, 1916, VII.

We found the same true of the hearing of direction, the sense of pitch, the sense of touch, and the sense of weight. This goes to show that the fundamental capacities of the senses are early developed to their maximum and that further development takes place not in the fundamental capacities but in the use of these capacities in more complex forms.

Evidence: the case of musical training. To these striking testimonials to the elemental character of intensity discrimination, we may add the records of children of the seventh and eighth grades who were classified on the basis of the amount of training, as above, and on the basis of intensity discrimination. In this we find a trace of agreement in the form of a tendency for those who have had extensive musical training to rank higher than those who have not. But the tendency is slight and is easily accounted for on the theory that those who have a keen appreciation of sounds have gravitated toward the opportunities of musical training.

An elemental capacity. If we take these three lines of testimony together, what do they mean? They mean that this intellectual capacity which we have measured is, in this form, relatively simple and direct, so that the most efficient exercise of it may be gained through the ordinary experience of everyday life to such an extent that specialized training after early childhood would not result in improvement. On the other hand, just as in the case of the sense of pitch, this capacity is one of the basic elements with which learning begins. Training in the hearing and execution of music, in so far as it comes through variation in intensity, offers an unlimited field for acquisition of insight and mastery through training in the complexes of intensity. The blind, who are thrown upon the auditory resources as a

substitute for the visual, find marvelous avenues for advancement in their power to guide themselves by intensity; but by so doing, they do not improve appreciably their native sensory capacity; they simply learn how to use it in progressively more complicated and meaningful forms.

X. Musical Significance

Factors involved. What is, then, the meaning of these tests for guidance in music? Partial deafness presents countless phases in respect to its significance for music. In diagnosis and prognosis, we must take into account the degree of insensibility; the variation of this for each and every segment of the pitch range; whether it is loss of acuity or loss of discrimination, or both; whether it is acute, chronic, or permanent; what relation the defect will have to the demands of the musical situation under consideration; and what relation this talent holds to measured or observed capacity in other musical talents. A person who has once heard and has become deaf has stored up sound imagery which may enable him to live in music to a surprising degree. But a congenitally deaf person cannot acquire any adequate conception of music.

The limitation it sets. Musical hearing, like the appreciation of painting, is essentially reconstructive imagination which merely gets its cue from the sensory impressions. One who hears musically may be fantastic and fastidious in the differences of intensity he attributes to sound and yet be inferior in the actual observation of such differences when they really exist; but, when it comes to singing or playing, this artistic license ceases and the effective performer is limited by his capacity for precision in the hearing of the shades of stress which he seeks to convey.

CHAPTER IV

THE SENSE OF TIME

I. Introduction

Time in musical hearing. Time enters into music in two forms, the apprehension of time and the expression of time. Of the former we have all kinds and degrees, from distinct consciousness of specific time intervals or duration to the most diffuse ramifications of time as undifferentiated elements of feeling. The latter also runs the gamut from consciously time-controlled action to the diffuse temporal reverberations of a large variety of organic reactions and other bodily movements in the emotional expression of rhythm.

Timed action. The capacity for keeping time manifestly rests upon the capacity for sensing time, but it also posits other powers, such as motor control and motor impulse. Possession of a keen sense of time is no guarantee of ability to sing or to play in time; but defective sense of time must result in corresponding defect in marking of time in any form.

Feeling of time. Sense of time is a basic condition of the perception of rhythm and rhythmic action, which are both complex and involve other factors as basic as the sense of time itself. However, as will be pointed out later, precision in the sense of time is not essential to the feeling of rhythm,

which may be very pronounced without involving any marked power of precision in the apprehension of time.

Judgment of time. Perception of short and regular intervals of time as in music is an immediate impression, whereas the estimate of longer intervals of duration is a matter of inference on the basis of a very complex set of associations. We must distinguish the process involved in the sense of musical time and that involved in the estimate or judgment of the time of longer periods, as these represent different capacities.

Restrictions. For the present purpose we must distinguish the sense of time particularly from the ability to keep time, from the feeling of time in rhythm, from rhythmic performance, and from time estimate or the ability to judge duration of prolonged intervals, such as minutes or hours.

II. Nature of the Sense of Time

Definition. With these demarcations in mind, we may say that, musically, the sense of time is the natural capacity for precision in the hearing of the duration of tones or short time intervals. As will be shown in this chapter, there are large individual variations in this capacity. What is the cause of these variations? What is it that varies? Manifestly it is not the sensory mechanism of the ear as in the case of the sense of pitch and the sense of intensity. So long as the physical ear registers sounds, one ear probably receives and registers as accurately as another in time. We must, therefore, seek explanation of the capacity elsewhere.

A motor theory of time. The perception of musical time is usually of a motor nature. That is, when we hear the first interval, we respond to it by projecting ourselves into

the thing heard in some form of real or imaged action, and when the following intervals occur, we either repeat the same real or imaged movements or match them, as it were, with the one which is being produced. That is, the perception of equality or difference in two successive time intervals is not a process of matching the objective tones or their demarcations, but a matching of our present production of a tone with a repetition of the tone previously produced. If our actions in this matching coincide, we say the intervals are equal; if our internal repetition of the first member ends before or after the one with which it is matched, we remark a corresponding difference. Perception of equality or difference in musical intervals is not a passive, cold, or quietly cognitive process, but ordinarily a rather complex process of parrying in action either real or imaged. The experience of time, whether in the measured flow of successive quarter notes in the stately chorale or in the empty intervals marked by dripping water, is a balancing of movements in ourselves rather than a mere purely cognitive inspection of time or duration in the source of sound.

Nature of movement. These movements may be real or imaged, usually both. Real movements may be either inceptive or complete. The most characteristic inceptive movements are the innervation of the vocal cords and of accessory parts of the vocal apparatus for the vocal expression of the thing heard and the inceptive movements of finger, lip, or any other muscle involved in the instrumental reproduction. These inceptive movements may, of course, be actually executed, as in humming or whistling with a tune that is being heard; but ordinarily they do not result in sound and their existence is not noted. Indeed, some reader at this point may question the very fact of their

existence. That they do exist can be demonstrated by attaching a sensitive tambour to the throat or to some other moving part of the speech mechanism, and allowing a person to listen to the musical time without being aware of the object of the recording instrument. If properly adjusted, the sensitive lever of the instrument will beat the time that is being heard.

Degree of movement. The real movements may be gross, such as the stamping of the foot, the nodding of the head, the swing of an arm, or the beating of the time with the tongue. Far more numerous, and perhaps even more significant, are the actual sequences of stress and release in the muscles of the throat and tongue, even the deep-seated muscles of the chest and the abdomen, or the larger muscles of the thigh or the upper arm. The swaying of the body as a whole is merely an extreme form of the sympathetic action of the whole musculature of the body in the response to time. Like the inceptive movements, these larger movements are usually relatively unconscious. A person may beat time with some part of the body without being aware of it.

Imaged movement. The imaged movement which we shall discuss later under the head of motor imagery, is a mental picture of movement, either an exact reproduction of a past movement or an imaginary production. In listening to the chorale, for instance, the image of the motor processes which took place in listening to the first note is reproduced in the listening to the next simultaneously with the present response to the note which is being sounded. What actually happens then is that we are matching an imaged movement with an actual movement which is being performed, and if the two synchronize, we call the time equal.

Time imagery complex. The image is ordinarily complex,

combining motor, auditory, visual, and other content. What actually happens in recalling the hearing of the first note when listening to the second, is that we feel ourselves producing or responding to the note which is heard and we see the setting and the visible actions going on. In listening to the second tone, the first is present as an image, usually a very complex image produced through different senses in which the representation of the listener as acting is the dominant feature.

Effect of other imagery. Relative prominence of the motor, auditory, and visual imagery depends partly upon the type of the individual and partly upon the character of the time-marking instrument. If, for example, the time is marked by a metronome, the listener may be influenced most by the visual representation. But, in general, as we shall see later, whether the thing shall be seen, heard, or felt depends upon the imaginal type of the individual.

Immediate experience. In listening to time, we are quite unaware of such processes as have been described. We have rather the attitude of a child, who, in answer to the question, "How do you see?" says, "I see with my eyes." The general feeling we have in listening to time is that of receiving immediate impressions through the ear without being conscious of why or how we receive them. Unless we are trained in psychology, we may not note the inceptive movements or even the complete movement; much less do we realize that the images exist or play any rôle. It is the business of psychology in a case like this to deal with the concrete elements. The component features here pointed out constitute a means of self-expression, and the perception of time is an evaluation in terms of our own self-expressive movements, real or imaged.

Nature of individual differences. The significance of this analysis for the psychology of musical talent is evident. When we find individual differences, we are to explain these, not in terms of differences in the ear, but rather in terms of a characteristic set or predisposition of the individual, resulting in a particular degree of favorableness for the grasping of time intervals in terms of his own action.

III. Measurement of the Sense of Time

Time discrimination. The sense of time, or time discrimination, may be measured in terms of the least perceptible difference in the duration of musical tones, or of time intervals.

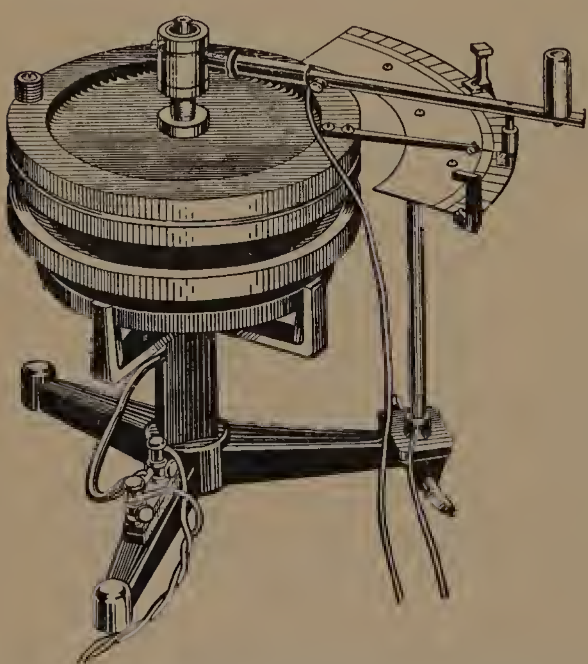


Fig. 1. — The Time-Sense Apparatus on a Synchronous Motor.

The apparatus. For this purpose, the best available instrument is the synchronous motor with the time-sense attachment, Figure 1.[1] The characteristic of a synchronous motor is that it runs at a constant speed.[2] This one, controlled by a tun-

[1] F. B. Ross, "The Measurement of Time-Sense as an Element in the Sense of Rhythm," Univ. of Iowa, Stud. in Psychol., 1914, VI.

[2] A high-grade phonograph motor is an excellent and convenient substitute for the synchronous motor (see Chapter VIII). A well-constructed pendulum also answers the purpose.

ing fork, runs one revolution per second within an accuracy of ±.0008 sec. The time is measured on the scale at the side, which is divided into hundredths of a second. A telephone receiver with battery is so connected with the apparatus that whenever the pointer projecting from the balance wheel at the top of the motor touches the downward projecting contact from the lever, a click is heard in the telephone receiver. The pointer on the balance wheel revolves one revolution per second, but the lever is free and may be held at any point on the scale by the hand. To secure accuracy of position, the two clamps on the scale plate are used as stops. The clicks begin when the lever is lowered and, if it is held against one stop, the apparatus will continue to mark exact seconds. To shorten an interval the hand swings the lever in a direction opposite to the revolution of the disk; to lengthen the interval it moves the lever in the other direction.

The group method. In testing a group of persons of different and unknown abilities, two time intervals are marked off by the sounding of three clicks. The problem is to tell whether the second time interval is longer or shorter than the first. The standard interval is 1.00 sec., and the varied interval is, in turn, 1.02, 1.05, 1.09, 1.14, and 1.20 sec. Whether the standard or the longer interval shall be sounded at first is determined by chance for all the trials in the test. Usually a test consists of two hundred trials, that is, forty trials for each increment. The record is kept in terms of per cent right answers for this entire block of trials. This per cent right is then treated as in the case of pitch in Chapter II, Table I, Figures 6 and 7. Norms are established by finding for each possible per cent right its equivalent percentile rank, its objective measure in terms of the least

perceptible difference stated in hundredths of a second, and the distribution or frequency of each measure.

Figures 2 and 3. The distribution of capacities in the sense of time as measured by the group method is shown in Figure 2. The norms for converting per cent right into rank are contained in Figure 3.

Individual differences. The individual variation in time sense is not so great as for pitch. A threshold of .01 sec. is an extraordinarily fine record in the sense of time. An

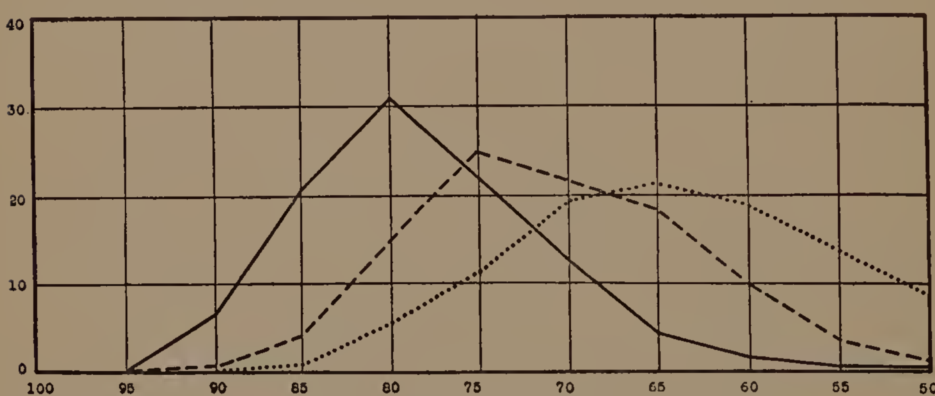


Fig. 2. — Distribution of Capacities for the Sense of Time.

Based on phonograph record Number A7538. Notation same as for Figure 6, Chapter II.

equally rare poor record is about .50 sec. That is, in such extremes, one has fifty times as good capacity as the other. Between these extremes, capacities range approximately, as shown in Figure 2.

IV. Relation to Age

The age factor. In general, children do not do so well as adults in this test. Among the factors which account for this are numerous conditions which are different in the group of children from those in a group of adults, such as the strain

of attention, the excitement, fluctuation of interest, and novelty, which tend to operate more adversely for children than for adults. But these are factors which need not so

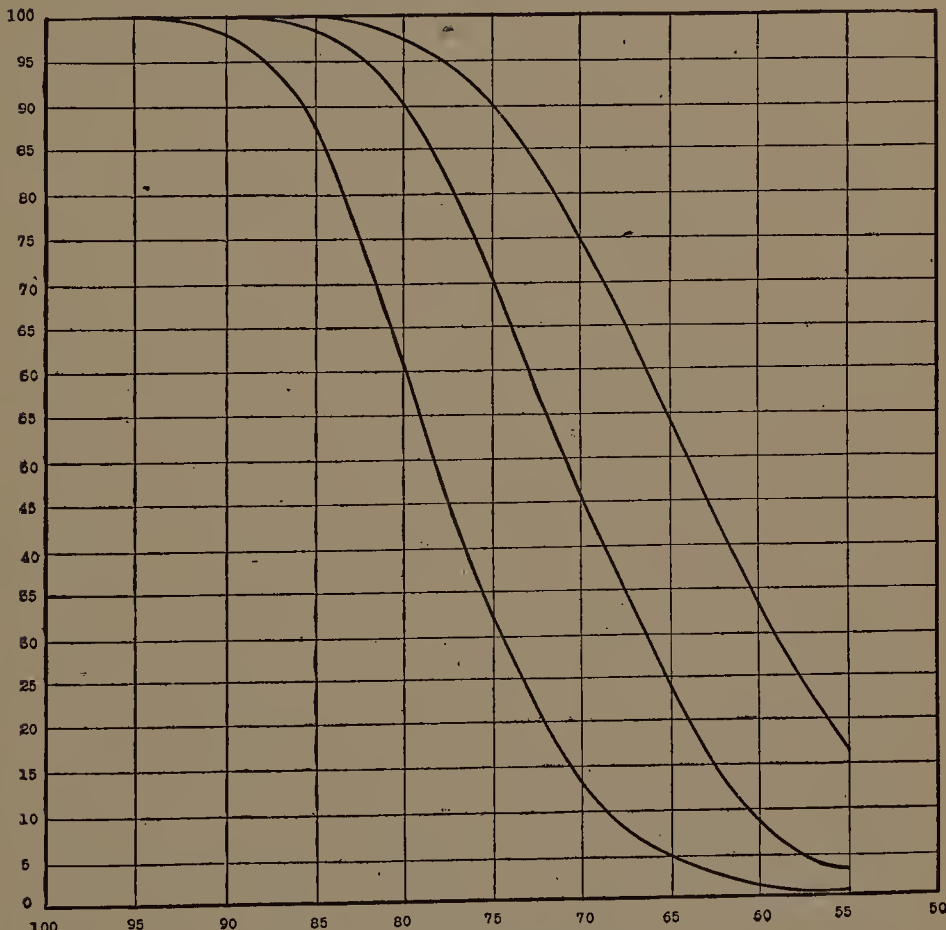


Fig. 3. — Norms for Sense of Time.

Notation same as in Figure 7, Chapter II.

operate in the ordinary spontaneous hearing of children, as in play and other acts of skill.

Explanation of this variation. As to variation with age, our general opinion on the ground of experimental evidence is that the sense of time is developed early in childhood

through the instinctive responses in play and other common activities, quite apart from music. At any rate, a naturally keen sense of time will manifest itself early in the life of a child, and the possession of it results in early exercise of this power and the formation of habits of precision.

V. Relation to Training

Nature of gain in training. As in pitch, training in the hearing of musical time is largely a progressive gaining of knowledge about the time forms and the development of habits in grasping more and more rich complexes of temporal forms. We have reason to think that the promise of gain through practice is in some degree proportional to the natural capacity as measured in the above test. If so, a person who ranks 10 per cent may earn a small increment with his talents, whereas a person who ranks 100 per cent may earn a proportionally larger increment.

Relation to music lessons. A comparison of the amount of musical training and the sense of time, on the same principle as for pitch in Table II, Chapter II, shows only a slight correlation. This may be interpreted in either of two ways: musical training does not seem to improve the elemental sense of time as measured in this test; or, there is but slight evidence to the effect that those who have a good sense of time are selected for musical education. In either case the musical educator will find a poser.

Relation to ability in singing. On the other hand, correlating the rating of the children in singing, as judged by their teachers, with measured capacity in time sense, we find a fairly marked tendency toward agreement. That means either that singing develops the sense of time or that those

who have a good sense of time tend to sing — unquestionably both.

VI. Relation to Intelligence

The elemental sense of time varies slightly with intelligence. This is shown by correlations of capacity in time sense with "brightness" as described above for pitch. This tendency toward agreement is accounted for largely by the fact that persons who are so dull as to lack power of concentrated application will make a poor record in the test although they may actually have a keen sense of time in their ordinary perception.

VII. Relation of Sense of Time to Sense of Pitch

In elaborate studies on this point, both among children and adults, we find but little correlation. Pitch and time may be regarded as fairly independent variables. The characteristic relationship expressed in the Pearson coefficient [1] amounts to r = 17, p. e. .04.

VIII. Musical Significance

This talent in related activities. It has been pointed out that this test is basic in that the real appreciation and expression of music presupposes such a power. Accurate determination of differences in this ability, therefore, point toward corresponding effects upon the power of appreciation and the expression of music, and it should not be limited to music alone, or even to hearing, for the time sense operates in many other adjustments, as through sight and touch, and individual differences in this sense may be of very far-reaching consequence in regard to the fitness of individuals for different kinds of occupations involving other senses

[1] See Brown, Wm., "Mental Measurement," Cambridge Univ. Press.

than hearing. It is a well-known fact that the person who has trouble with time in music is, as a rule, a poor dancer, awkward in military drill, and defective in many other types of skillful movements which depend upon precision in time.

Need of precision. It has been said that the appreciation of good music does not necessarily involve a keen sense of time because musical expression takes liberties with exact time; but the response to that is that it requires a keen sense of time to appreciate fully the graceful and artistic deviation from right time. Indeed, it requires a higher power than that of being merely mechanically exact. Mistakes in time, neglect of time, or irregularity of time cannot *per se* be regarded as beautiful. The sense of time is taxed particularly hard in the larger units of complex rhythms where artistic balances are sought.

Music classified on this basis. More stress is laid upon time in some forms of music than in others, and this is significant for vocational guidance in that we may find opportunities in music for those who have an inferior sense of time but possess other capacities. No place can be found in the orchestra for a person with a defective sense of time, while there is abundant room for a vocal solo and other rendition in which the performer is relatively free from the necessity of synchronism.

Significance of early rating. For purposes of guidance, the main thing of import is that the inborn, elemental sense of time is discoverable early in childhood; that there are large and fairly fixed differences in this endowment; that this talent as a basic capacity is relatively independent of age, training, and intelligence; and that the chances of musical achievement, so far as hearing of time is concerned, are probably roughly proportional to the natural talent.

CHAPTER V

THE SENSE OF RHYTHM[1]

I. The Nature of Rhythm

Definition. The sense of rhythm is an instinctive disposition to group recurrent sense impressions vividly and with precision, by time, or intensity, or both, in such a way as to derive pleasure and efficiency through the grouping.

A complex process. Rhythm is, thus, not an attribute of sensation, like time and intensity. It is a complex process and involves literally the whole organism in the form of responsiveness to measured intervals of time or tone. Rhythm as a whole presents two fundamental aspects, the perception of rhythm and rhythmic action.

Subjective rhythm. The perception of rhythm may be either subjective or objective. Subjective rhythm is the grouping of tones or time intervals which are absolutely uniform in time and intensity, quite as though certain of the notes were actually accented. This is a universal tendency which may easily be verified. If, for example, a series of tones of absolute uniformity in every respect be played, the listener will inevitably hear time in measures, for example, $\frac{2}{4}$ or $\frac{3}{4}$ time, and will actually hear the appropriate notes accented. A good illustration of this is found in a very crude way when one is lying in a Pullman sleeper

[1] Essentially as printed in *The Musical Quarterly*, Oct., 1918.

and the successive beats from the crossing of rail joints set up a rhythm which carries tunes that come into one's head. The rails seem, as it were, to beat the time emphatically into measures. The writer recalls once being haunted by the plantation melody, "What kind o' a crown you gwine to wear? Golden crown?" As he allowed the imagery of the melody to flow, the accentuation of the click of the rails became very prominent and insistent as a rhythm. One who has a highly developed sense of rhythm may, even in eating soup, feel the various movements divided into measures with their artistic grouping of long interval and short interval, some objectively and others only subjectively marked, with occasional cadences; yet a person watching the movement might not be able to see any rhythm in the actual movements.

Objective rhythm. The objective rhythm as we find it ordinarily in prose and poetry is marked by emphasis of time or intensity, or both. Occasionally it may be also through pitch, although that always involves intensity. It is probable that it may also come through other senses than hearing.

Rhythm personal. Subjective rhythm is more fundamental than objective rhythm and always plays a large rôle in the objective. This is the reason why we find rhythm more essentially a matter of personality rather than a matter of objective grouping. All rhythm is primarily a projection of personality. The rhythm is what I am. For him who is not endowed with this talent the objective workings of rhythm in nature and art are largely wasted.

Free and regulated rhythmic action. Rhythmic action we shall find divided into two large groups, free and regulated. Free rhythm is the temporal or intensive stress which

one naturally makes in free movements, whereas regulated rhythm requires, either consciously or unconsciously, the stressing by time or intensity in synchronism with set standards of time, or in conformity to set standards of stress.

Five basic capacities. While the perception of rhythm involves the whole organism, it requires primarily five fundamental capacities. The first two of these are the sense of time and the sense of intensity, corresponding respectively to the two attributes of sound which constitute the sensory media of rhythm. The third and fourth are auditory imagery and motor imagery, that is, the capacity for reliving vividly in representation the auditory experience and the motor attitudes respectively. The fifth is a motor impulse for rhythm, an instinctive tendency chiefly unconscious and largely organic. These five factors may be said to be basic to the sense of rhythm. Other general factors, such as emotional type and temperament, logical span, or creative imagination, are intimately woven into the warp and woof of rhythm, but we shall probably find that these are secondary to the primary and basic forces named.

II. What Rhythm Does

Process of analysis. To gain some insight into the actual nature of rhythm, it may be well to point out some of the things that rhythm does on the side of perception as distinguished from action, which will be the equivalent to pointing out the sources of pleasure and means to efficiency in rhythm.

Rhythm favors perception by grouping. It has been demonstrated that under happy grouping one can remember approximately as many small groups as one can remember

individual objects without grouping; for example, in listening to a series of notes, one can grasp nearly as many measures, if they are heard rhythmically, as one could grasp individual sounds, if they were not heard rhythmically. This is a principle which is involved in all auditory perception. Individual sounds are grouped in measures and phrases, phrases and periods, periods and movements, etc. The ability to grasp in terms of larger and larger units is a condition for achievement. The development of this ability results in power to handle vast numbers of sounds with ease, and such success is a source of pleasure. This is true not only in poetry and in music but in our natural hearing, even under primitive conditions. Thus, rhythm has become a biological principle of efficiency, a condition for advance and achievement and a perpetual source of satisfaction. This satisfaction need not be conscious. The rhythm need not be conspicuous in order to be effective. In music and poetry we play with rhythm, as it were, and thereby develop it in expansive and artistic forms.

Rhythm adjusts the strain of attention. In poetry and music, for instance, the rhythm enables us to anticipate the magnitude of units which are to be grasped. This in turn makes it possible to adjust the effort in such a way as to grasp the unit at the strategic moment and to relax the strain for a moment between periods. Of this, again, we may not be immediately conscious, but it may be readily demonstrated by experiment, as, for example, if we should break up a measure as in going from $\frac{2}{4}$ to $\frac{3}{4}$ time without warning. The ordinary measure in poetry and music is determined by what is known as the attention wave. Our attention is periodic. This can be demonstrated in a variety of ways and reveals a characteristic of all our attention,

namely, that it flows not in a steady stream but by jets. This is a principle which is made use of in nature and in industry, as, for example, the lighting current. The current which energizes our lamps, is not, as a rule, a steady so-called direct current, but is "alternating," that is, coming in pulsations, usually about sixty a second, which is frequent enough to give us the impression of continuous illumination. Moving pictures illustrate the same principle. The rhythmic measure, then, is simply a taking advantage of nature's supply of pulsating efforts of attention. And when the measure fits the attention wave it gives us a restful feeling of satisfaction and ease. This in turn results in what is known as secondary passive attention, which is more economical and more efficient than voluntary attention. Thus, it comes about that we acquire a feeling of ease and power and adjustment when we listen to rhythmic measures because we get the largest returns for the least outlay, and the tendency to seek this assumes a biological importance because it tends to preserve and enhance life.

Rhythm gives us a feeling of balance. It is built on symmetry, and when this symmetry involves within itself a certain element of flexibility which is well proportioned, we have grace. When we read an ordinary prose sentence, we pay no attention to the structural form; but when we scan the dactylic hexameter, we fall into the artistic mood, distinctly conscious of a symmetry and beauty in form, and in this sense rhythm becomes a thing in itself. Poetry may contain ideas and music may represent sentiment; but the rhythmic structure is in itself an object of art, and the placid perception of this artistic structure takes the form of the feeling of balance under various degrees of delicate support. Children sense the rhythm of poetry before they do its meaning.

Rhythm gives us a feeling of freedom, luxury, and expanse. It gives us a feeling of achievement in molding or creating, of rounding out a design. This sense of freedom is in one respect the commonplace awareness of the fact that one is free to miss the consciousness of periodicity in countless ways, yet chooses to be in the active and aggressive attitude of achievement. As our eye scans the delicate tracery in the repeated pattern near the base of the cathedral and then sweeps upward and delineates the harmonious design continued in measures gradually tapering off into the towering spire, — all one unit of beauty expressing the will and imagination of the architect; so in music, when our ear grasps the intricate rhythms and follows them from the groundwork up through the delicate tracery into towering climaxes or clustered pinnacles of rhythmic tone figures, we feel as though we did this all because we wished to, because we craved it, because we were free to do it, because we were able to do it.

Rhythm gives us a feeling of power. Rhythm carries. It is like a dream of flying; it is so easy to soar. One feels as if he could lift himself by his boot straps. The pattern once grasped, we have an assurance of ability to cope with the future. This leads to a disregard of the ear element and results in a motor attitude, a projection of the self in action; for rhythm is never rhythm unless one feels that he himself is acting it, or, what may seem incongruous, that he is even carried by his own action.

Rhythm stimulates and lulls. Pronounced rhythm brings on a feeling of elation which not infrequently results in a mild form of ecstasy or absent-mindedness, a loss of consciousness of the environment. It excites and it makes us insensible to the excitation, giving the feeling of being lulled.

This is well illustrated in the case of dancing. Seated in comfort and enjoyment in pleasant conversation, the striking up of a waltz is a call which excites to action. It starts the organic, rhythmic movements of the body the moment it is heard and one is drawn, as it were, enticingly into the conventional movements of the dance. But no sooner is this done, in the true enjoyment of the dance, than one becomes oblivious to intellectual pursuits, launches himself, as it were, upon the carrying measures, feels the satisfaction of congenial partnership, graceful step, freedom of movement, action without any object other than the pleasure in the action itself. There comes a sort of auto-intoxication from the stimulating effect of the music and a successful self-expression in balanced movements sustained by that music and its associations. The same is true of the march. When the march is struck up, it stimulates tension of every muscle of the body. The soldier straightens up, takes a firmer step, observes more keenly, and is all attention; but as he gets into the march, this passes into its opposite, a state of passivity, obliviousness to environment, and obliviousness to effort and action. The marked time and accent in the music of the band governs the movements of all parts of the body in happy adjustment. He can march farther than without the music, in better form, and with less fatigue.

Rhythm is instinctive. As we saw above, the grouping into natural periods of the flow of attention is a biological principle of preservative value. It is likewise true that the tendency to act in rhythmic movements is of biological value, and for a similar reason. If one does not know where to put his hand or foot in the next movement, he is ill at ease and will be inefficient in the movement; but if move-

ments may be foreseen and even forefelt, and an accompanying signal sets off the movement without conscious effort, then results a greatly lessened expenditure of energy, a more effective action, and a feeling of satisfaction. Anything that accomplishes these ends in the life of a species will tend to become instinctive, to develop a natural tendency always to move in rhythmic measure; and, when our movements are not actually divided into objective periodicity, it tends to appear in a subjective rhythm. We cannot have adequate perception of rhythm without this motor setting. The bearing of this instinctive motor tendency on the perception of rhythm lies in the fact that with the motor instinct goes an instinct to be in a receptive attitude for the perception of such rhythms, both subjective and objective.

Rhythm finds resonance in the whole organism. Rhythm is not a matter of the ear or the finger only; it is a matter of the two fundamental powers of life; namely, knowing and acting. And, therefore, indirectly it affects the circulation, respiration, and all the secretions of the body in such a way as to arouse an agreeable feeling. Herein we find the groundwork of emotion; for rhythm, whether in perception or action, is emotional when highly developed, and results in response of the whole organism to its pulsations. Such organic pulsations and secretions are the physical counterpart of emotion. Thus, when we listen to the dashing billows or the trickling raindrops, when we see the swaying of the trees in the wind, the waving of the wheat fields, we respond to these, we feel ourselves in them, and there is rhythm everywhere, not only in every plastic part of our body, but in the world as we know it at that moment.

Rhythm arouses sustained and enriching association. One need not saunter through the woods where the Wagnerian scenes are laid in order to experience the rich flow of visual association with a rhythmic flow of music in Lohengrin. In most persons it comes irresistibly through free imagination. Our consciousness of pleasure in music is often a consciousness of seeing and doing things rather than a consciousness of hearing rhythm, the tendency being to project ourselves through the sensory cue of hearing into the more common fields of vision and action.

Rhythm reaches out in extraordinary detail and complexity with progressive mastery. Rhythm makes use of novelty. The simple rhythms soon become monotonous, but one can find endless opportunity for enrichment by the complications of which the measure, the phrase, or the more attenuated rhythmic unit is capable. This is true both for perception and for action. A rhythmic nature tends to live more and more in the exquisite refinements and far-reaching ramifications of rhythmic perceptions and rhythmic feelings of movements, real or imagined. This power to encompass may be vastly enhanced by training in the rhythmic arts. The sense of rhythm is like the instinct of curiosity: it takes one into wonders after wonders. Curiosity asks one question of nature and nature asks her two. One degree of rhythmic perception acquired becomes a vantage ground from which we may approach higher levels, and each of these traversed in turn leads to higher vantage grounds, level after level, vista after vista.

Rhythm a primary motive for play. The instinctive craving for the experience of rhythm tends to result in play, which is the free self-expression for the pleasure of expression; or, as Ruskin puts it, "exertion of body or mind,

made to please ourselves, and with no determined end." It makes us play, young and old. It determines the form of play, in large part. Through play it leads to self-realization by serving as an ever-present incentive for practice.

Aim of the inventory. This inventory of the sources of pleasure in rhythm is fragmentary and inadequate, but it should at least accomplish two ends. It should dispel the notion that the perception of rhythm is a simple mental process or action, and should make us realize that to the person who is endowed with this gift in a high degree, it is one of the great sources of pleasure, not only in music and art, but in the commonplace humdrum of life. To a person who is not so endowed this rôle of rhythm may be no more concretely patent than the ever-presence of color is to the color blind.

III. Measurement of the Sense of Rhythm

Three methods of approach. That enormous individual differences in this endowment obtain is a noted, if not notorious, fact. There are three ways of approaching the problem of concrete analysis or measurement for the purpose of securing reliable information about the relative presence or absence of this talent.

First. The capacity for rhythm rests upon certain fundamental powers which can be measured serviceably in various forms. Of these we have already indicated the method and the significance of the measure of the sense of time and the sense of intensity. These are measures of capacity for precision in the perception of rhythm. Auditory imagery and motor imagery, as we shall see later, may also be measured serviceably. These two are measures of the capacity for realistic vividness, one of the flow of sound,

the other of the motor response to that sound in the perception of rhythm. These two measures of basic capacities taken together constitute a fair index to the degree and type of rhythmic sense present. While we have no precise measure of the motor impulse, which is the motive power in the perception of rhythm, there are serviceable methods of rating it. The motor aspects will be discussed in a later chapter.

Second. There are a number of tests which measure actual precision in the perception of rhythm. Perhaps the best of these is one which is analogous to the sense of time test, described above. The same instrument and the same method may be employed as in time sense except that, instead of having uniform time intervals, we have the rhythmic divisions into long and short, for example, two quarter notes and a half note. Four such measures may be given as a standard and, in the fifth, the half note may be made either too long or too short, the test being to determine the accuracy in the perception of the long intervals. This is a specific measure of precision in temporal rhythmic perception. Similar tests may be made for the attribute of intensity, but it must be remembered that these tests are merely measures of precision and not measures of the richness of rhythmic experience.

The methods to be explained for the measure of auditory and motor imagery may also be extended in such a way as to give us tests for the capacity for vividness, stability, and fullness of the rhythmic representation in actual rhythmic setting. For experimental purposes many of these measures are serviceable, and may be valuable; but, for the discovery of individual differences in guidance, they probably take us too far into detail, unless we are to make a very exhaustive analysis.

Third. A musician, who knows his own capacities in rhythm, ranks high in sensitiveness to rhythm, and has a psychological insight into the nature and structure of the sense of rhythm, has in music itself abundant means for observing the child's capacity and, indeed, abundant situations which should enable him to analyze the talent for rhythm into its chief components and enable him to rate the various traits for practical purposes. In fact, he need not wait for music, but he may analyze these powers as they are revealed in the spontaneous play of the child.

Vividness and precision. For guidance in music there are, then, two fundamental kinds of rhythmic perception. One is vividness and the other is precision. A person may have effusive rhythmic feeling in the perception of music and live himself into it most realistically and yet not have any capacity for precision. Likewise one may have fine capacity for precision in rhythmic perception and yet not have the vivid emotional experience of the rhythm. Between these extremes we have many types of rhythmic hearing, both qualitatively and quantitatively.

Significance in musical rating. Although the sense of rhythm responds to training, there are very great individual differences in capacity for achievement. From the point of view of quantitative analysis, two factors must be borne in mind: first, that the relative presence or absence of one or more of the basic capacities for rhythm determines the permanent traits of the developed musical mind in rhythm; and, second, that the relative presence or absence of such capacities in childhood may be regarded as a fair index to achievement, or the ability to profit by rhythmic training.

CHAPTER VI

THE SENSE OF TIMBRE

I. Definition of Terms

Form of the sound wave. Three preceding chapters have dealt in turn with those attributes of tone which are due respectively to the frequency, the amplitude, and the duration of the sound waves. We shall now turn to those characteristics of a tone which are due primarily to the form of vibration. These are generally spoken of as the timbre, quality, clang tint, tone color, or character of the tone.

Quality and timbre. The term "quality" has been used in physics, music, and common speech to designate those tone characteristics which are due to the form of the sound wave; but psychologically this is incorrect, because the quality of a tone is its pitch, just as color is the quality of visual and taste is the quality of gustatory impressions. This is merely a statement of fact, showing that the common use of the word is wrong. The French word *timbre,* meaning a stamp or mark, is adopted in the English language as a more technical and psychologically appropriate substitute for the term "quality." In so far as timbre is merely a complex of pitches, we might speak of simple, or pure, quality (pitch) and complex quality (timbre); or primary quality (pitch) and secondary quality (timbre). But, in the interest of science, we must accustom ourselves to the more general use of the word "timbre" because it is specific.

Nature of timbre. Timbre, then, covers all those tone characteristics which range through the practically infinite variety of pitch complexes in a single tone, from the pure tone at one extreme, through all the degrees of musical richness of tone, to the noise or toneless sound at the other. We shall be helped in our orientation in this field if we keep clearly in mind two concepts: first, that, psychologically, timbre is to be understood and explained as a complex of pitches fused into a single tone; and, second, that, physically, timbre is expressed in terms of the form of a sound wave. We may begin our study with the pure tone and trace from that the gradual building of complex impurities and richness of tone, even down to the non-tonal characteristics which we call noise.

II. Purity

Pure tones. A pure tone is one which is caused by smooth, uniform waves, usually described as a sine-curve, or pendular, because the sounding body, such as a tuning fork, acts like a pendulum, and a tracing from the tip of its prong produces the characteristic sine-curve as in Figure 1, Chapter II. Musically, a pure tone is thin, smooth, stable, and free from overtones and noises accessory to the fundamental pitch. It can be defined accurately because it is simple and constant.

Useful in exact work. In experimental work of physics, music, and psychology, when it is necessary to define and control the timbre accurately, the pure tone is used extensively, and should be used wherever possible because it is the most elementary form of tone character. Pure tones may be produced by a variety of means available in a technical laboratory; but the most common means in use is the

tuning fork with the resonator, as in Figure 5, Chapter II. The tuning fork of itself emits a relatively pure tone, but this is further refined by the selecting power of the resonator which throws the true tone into strong relief and does not reënforce partial or accessory tones.

Rôle in music. Pure tones are rarely used in music, partly because they cannot be produced by the voice or the ordinary musical instruments, and partly because they are thin, that is, they lack richness and flexibility. But purity in itself possesses a charm in music and is often an ideal goal in musical tone production, both vocal and instrumental. The choralcello is a new "piano" remarkable for the fact that through the operation of certain magnetic devices it produces relatively pure tones like those of tuning forks.

III. Overtones

Overtones explain timbre. The richness of musical tones is due to the presence and relative distribution of overtones. There is no more fundamental and far-reaching principle of interpretation of tone character than that of the overtone. The overtone accounts for the production of vowels, for all timbre differences in instruments and voice, and for the infinite variety of possibilities of change in timbre in speech and music, as well as in the infinite range of sounds in nature.

Nature of overtones. The physical counterparts of the overtones are called partials. When a string, a bell, a reed, the human vocal cord, or any other sound-producing body vibrates, it vibrates not only as a whole but also in parts. This may be illustrated in the case of a vibrating string, as in the violin. When the string is bowed it divides itself into segments, each of which has a vibration frequency of its own, inversely proportional to its length. It vibrates

as a whole, yielding the fundamental pitch of the clang; it, also, vibrates in halves and thirds; each of these segments also vibrates in halves and thirds; each of the resulting segments also vibrates in halves and thirds, and so on. Consequently, under favorable conditions, the string may be active in from twenty to thirty segments. Each segmental vibration is called a partial and is heard as an overtone. Theoretically there are as many independent tones as there are segments of the string; and, by experiment, they may be isolated and heard one at a time. Practically

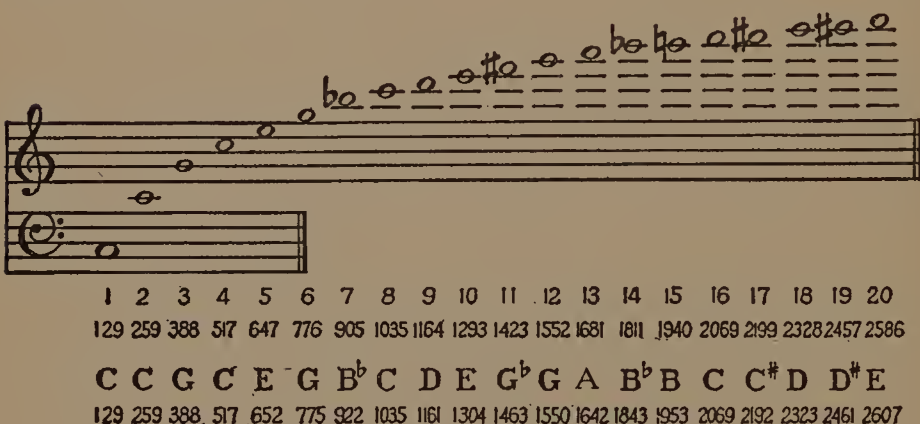


Fig. 1. — A Series of Overtones (Miller).

they fuse into one rich tone, because the partials stand in a harmonic series and are subordinated to the fundamental which is regarded as *the* recognized tone or pitch. Such a series is shown in musical notation in Figure 1.

Analysis of a complex wave. Some really wonderful work has been done recently in the analysis of tones, in which it is demonstrated that we can photograph the sound of any instrument or voice and apply a mechanical analyzer to the photograph of the wave in such a way as to get an actual tracing of all the component overtones involved in

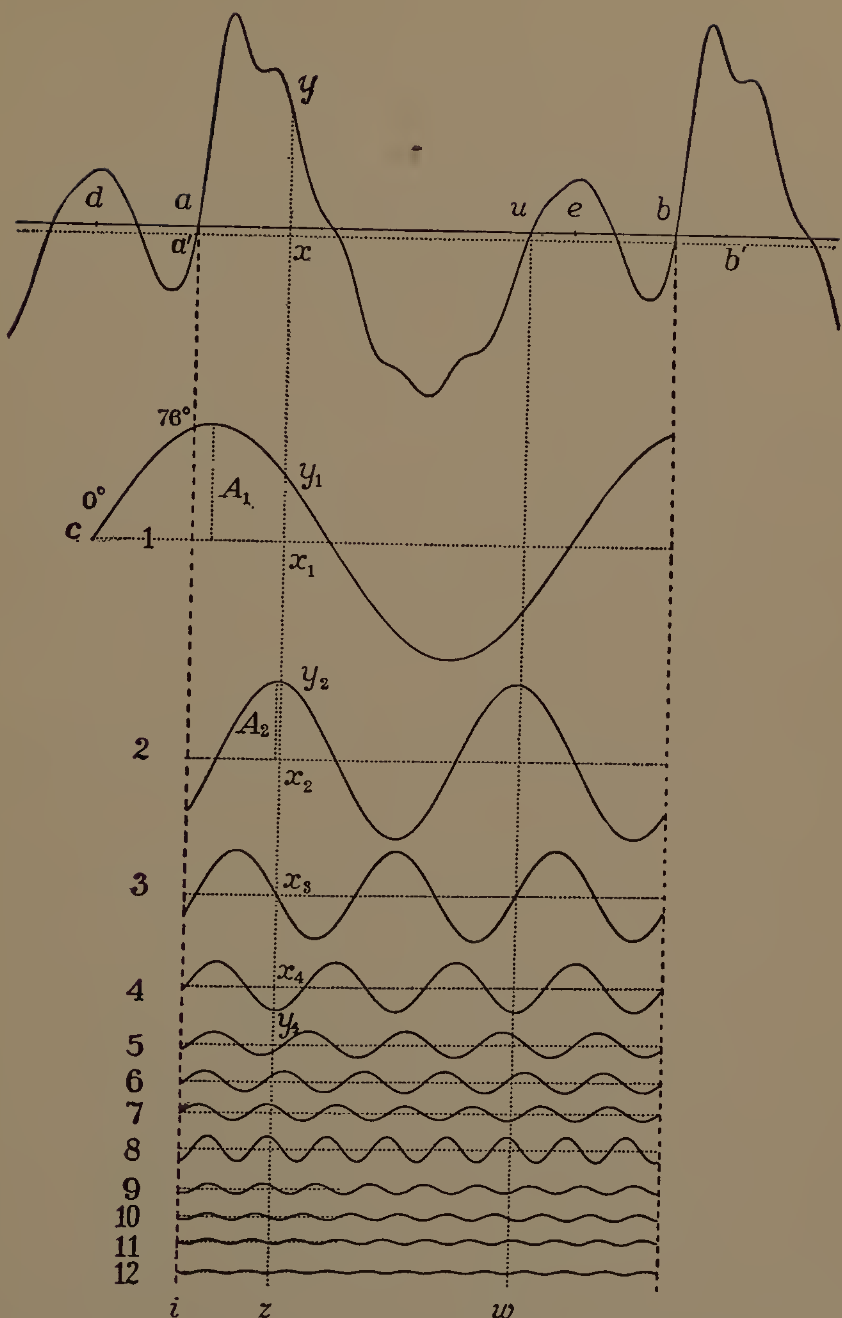


Fig. 2. — A Complex Sound Wave Analyzed into Its Components (Miller)

that tone. Every rich and musical sound wave has a series of irregularities corresponding exactly to the number and force of the overtones present. A true photographic or other form of record of a single wave is, therefore, an accurate representation of the timbre of the tone.

An example. In Figure 2 the complex sound wave of an organ tone is analyzed into its harmonic components. The irregular wave at the top is the form of the actual wave as photographed. By the application of the instrument known as the "tone analyzer"[1] to the wave, its twelve component partials may be determined showing the pitch of each overtone in terms of the length of the wave (or its reciprocal, frequency), and the relative prominence of each overtone in terms of the amplitude or height of the wave. Here 1 is the fundamental, 2 the octave, 3 the twelfth, etc.

Reconstruction of the wave. By a companion instrument, the "tone synthesizer," the process may be reversed; given the number and intensity of each overtone it is possible to reconstruct the complex wave. Any number of independently determined overtones in a rich tone may be combined into a single resultant, the exact form of the original complex wave such as that at the top of Figure 2. Proof of this is seen in Figure 3. The light curve represents a photograph of a sound wave. This was analyzed into its components as in Figure 2 by the "analyzer." Then these components were recombined by the "synthesizer," with the result that the black pen-tracing of the reconstructed chart practically coincided with the original photograph — certainly a wonderful achievement in the dissection and the reconstruction of a tone.

[1] For the best illustrations and explanation of this process see D. C. Miller, "The Science of Musical Sounds," The Macmillan Co.

The proof of division is multiplication. One of the prettiest proofs of this analysis of tones is found in the fact that, with a harmonic series of tuning forks or pipes, it is possible to speak all the vowels. That is, by emphasizing certain overtones we may get the tuning forks to say, even more accurately than the human voice, a, e, i, o, u, and their numerous phonetic variants.

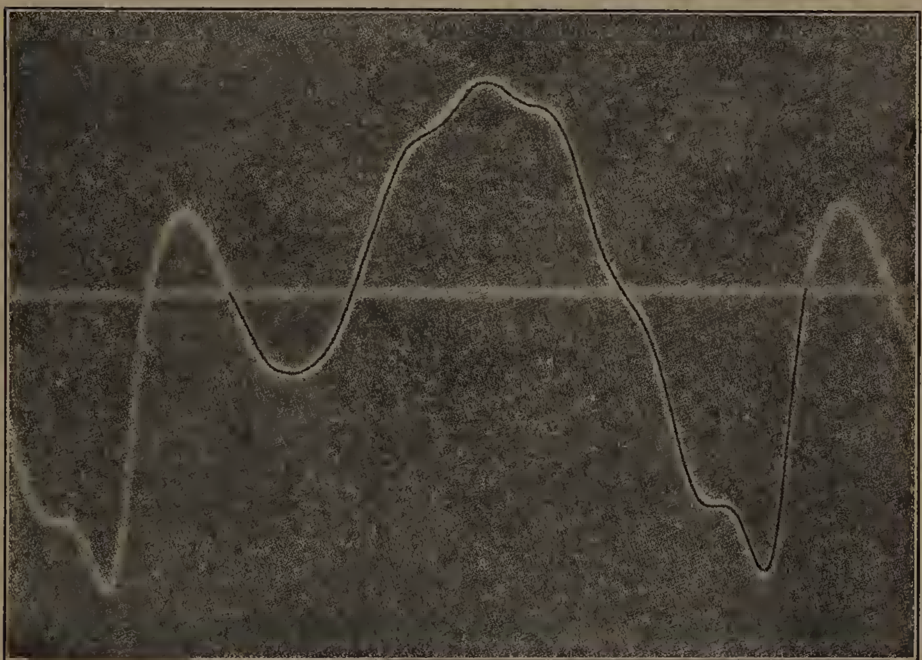


Fig. 3. — The Reconstruction of a Complex Sound Wave from Its Components (Miller).

The illustrations, Figures 4–9, show how clearly one instrument or voice is distinguished from another by its wave form.[1] Each of these wave forms (tuning fork, violin, oboe, clarinet, bass voice, soprano voice) can be analyzed into its component partials, as was done for the organ tone, Figure 2.

[1] All taken, by permission, from Miller.

Fig. 4. — Photograph of the Simple Sound Wave from a Tuning Fork (Miller).

Fig. 5. — Photograph of the Sound Wave from a Violin (Miller).

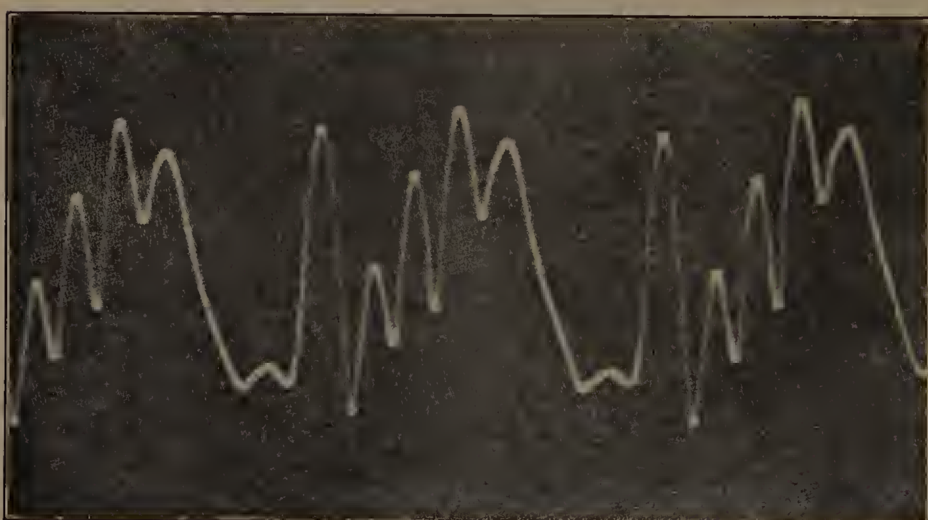


Fig. 6. — Photograph of the Sound Wave from an Oboe (Miller).

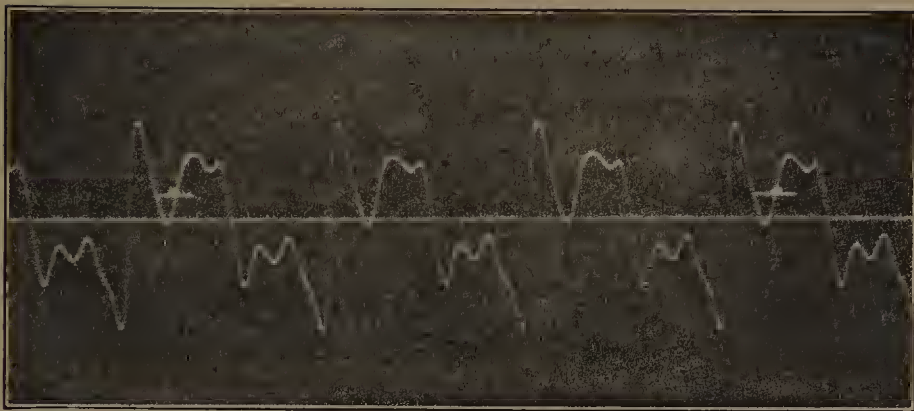


Fig. 7. — Photograph of the Sound Wave From a Clarinet. (Miller.)

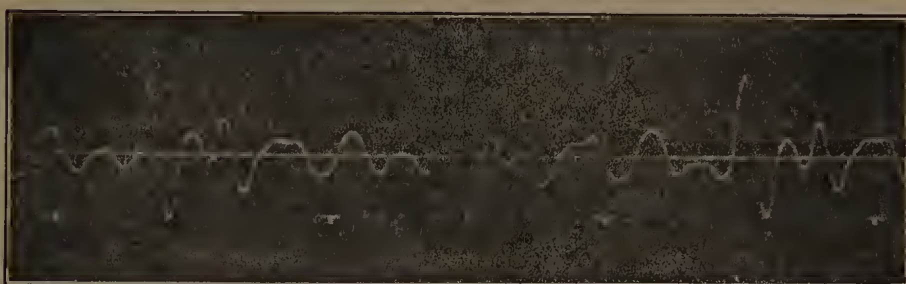


Fig. 8.— Photograph of a Bass Voice. (Miller.)

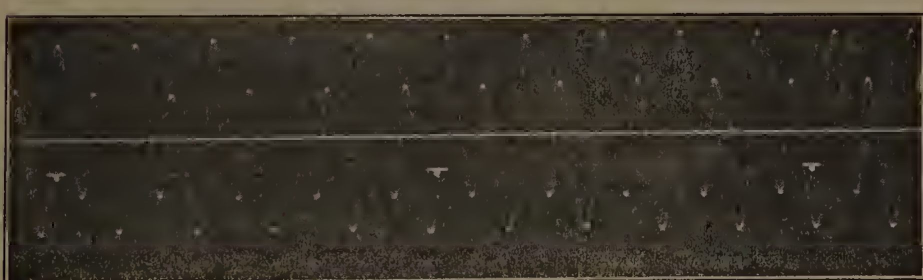


Fig. 9. — Photograph of a Soprano Voice. (Miller.)

No excuse for vagueness. In view of this clearness of conception there is no excuse for the almost universal ambiguity and confusion about the character of tones which we find in discussions of music and particularly in the practical terminology of the profession. If the nature of timbre

is clearly understood, one can speak of it even in exact and quantitative terms technically and certainly in clear and constant terms in a general discussion. Timbre is nothing vague, but something which can be defined with precision and spoken of in exact terms, namely, the number and relative prominence of overtones.[1]

Is there any wonder that there is confusion of theory about the teaching of timbre in tone-production?

IV. Measurement of the Sense of Timbre

Indirect measurement. The sense of timbre involves primarily a keen sense of pitch because, whether consciously or unconsciously, the hearing of timbre is the hearing of a series of overtones present in a clang. But the sense of

[1] Contrast this with the conception of timbre shown in the following account of timbre found in a book entitled "Practical Psychology of Voice and of Life," recently written by a prominent musician and published by one of the best music firms:

"What is the 'timbre'? It is difficult to describe; as mentioned before, it arises out of the principle of the 'liaison' in the French language. The old Italians were careful to make all the notes join, but the timbre is something more; it suggests an enveloping overtone which comes to a rounded point in the forward dome of the face, 'dans le masque,' as the French say. There is a strong vibration felt in the masque of the face, at a point immediately back of the nose, just under the eyes. I do not quite like to call it the hum in the voice, as that rather implies weakness, while the timbre gives strength; it is the forward humming ring, or ringing hum, which gives intensity and carrying power solidity and character, whether the voice is loud or soft. It is powerful and insinuating, making it possible for the voice to be heard through a mass of orchestral sounds. It is the ring in the voice, the opposite of the shout. It is the natural overtone which bears the same relation to the fundamental tone as the spirit does to the body; it is the astral body of a tone which carries the message from the singer to the audience. It gives the divine spark which kindles sympathy in all within hearing, and its presence assures the singer that there is complete connection between his inner soul-forces and his outer means of expression. Without it no really expressive artistic singing can be done."

pitch does not necessarily guarantee a keen sense of timbre, because the latter depends also upon the possession of a certain degree of ear-mindedness. This ear-mindedness is not a simple or clearly analyzed concept. We shall discuss it under the head of auditory imagery and must content ourselves for the present with the mere statement that it represents a natural bent of mind for attention to tones and to the analysis of them in a concrete way. The sense of timbre also posits a certain degree of the sense of intensity. For most practical purposes we shall have a correct index to the sense of timbre in terms of the sense of pitch and the sense of intensity, which we have studied, together with auditory imagery which we shall discuss later.

Direct measurement. If, however, we wish to test the sense of timbre by itself as a complex process, we may proceed in the following manner. Take a series of five tuning forks representing the low tones in a harmonic series and sound them together into a telephone with a person listening at a receiver in another room. The transmission through the telephone tends to fuse the five tones into one. We can then vary the " mixture " by strengthening or weakening the relative intensity of one of the five forks, which are being sounded simultaneously, and sound, in a succession of one or two hundred trials, a given standard about half of the time, and, in the other trials, a series of increments in the strength of the varied overtone, so graded as to be easy enough for a poor ear and difficult enough for a very good ear. Then we proceed by the method described above to find the per cent of right cases.

Limitation usually on motor side. As stated above, given a reasonable sense of pitch and sense of intensity,

together with auditory imagery, one may be practically certain of the natural capacity for the sense of timbre. Musically, the main crux is on the motor side, that is, the ability to produce a set tone quality; at least 75 per cent in a normal community have a sufficiently good ear, for practical purposes in music, for the hearing of timbre, whereas only a small percentage in the normal community have the capacity of producing good timbre either by voice or by instrument.

Summary. In brief, then, timbre is due to the form of the sound wave. The form of the wave is due to the number of overtones and their relative intensity. Each overtone may be thought of as an independent tone of a given pitch, and the effect that each overtone shall have upon the form of the sound wave depends upon its pitch and its relative intensity. The hearing of timbre, therefore, gives no new attribute of sound; a tone of a given timbre is merely a complex of a given number of pitches in their respective intensities, usually blending into the experience of a single tone.

CHAPTER VII

THE SENSE OF CONSONANCE

We have seen that what is ordinarily spoken of as a single tone is really a clang, a very rich complex of tones. When we pass to the subject of consonance and deal with two tones sounding simultaneously we introduce certain factors in addition to that of the harmonic series of overtones.

I. Combination Tones

Beats. In the first place we have the phenomenon of beats. When two notes such as c–c♯ are sounded together they produce a rough combination in which the beats are conspicuous. These beats are caused by the interference of one series of vibrations with the other. Thus, if we sound two tuning forks, one 435 d. v., and the other 436 d. v., the resulting tone will be a pulsation swelling into a loud tone once a second and coming almost to silence between these pulsations. The physical explanation is that during a part of a second the two wave phases reënforce each other; and produce a relatively strong resultant; whereas, in the other part, they interfere with each other, and this interference results in relative silence.

The first difference tone. When these beats become rapid, they gradually fuse and we get what is known as a difference tone so that, if two tones, from, *e. g.*, c′, 256 d. v., and e′, 320 d. v., we get not only two tones, c′ and e′, but a combination tone, the pitch of which is represented by the

differences in the vibration frequency in the two tones, in this case a tone of 64 d. v. This tone, known as the first difference tone, or Tartini's tone, is illustrated in Figure 1 from Titchener,[1] who furnishes excellent directions for those who wish to demonstrate these combination tones experimentally. The first difference tone is expressed by the formula $d^1 = h - 1$, where d^1 denotes the first difference tone, and h the higher and 1 the lower of the two tones in a two-clang.

The second difference tone. For each two-clang there is another combination tone called the second difference tone. This is expressed by the formula $d^2 = 21 - h$. For example, in the above case the two-clang, 256 d. v. and 320 d. v., would yield a second difference tone of $2 \times 256 - 320$, or 192 d. v. Some examples are given in musical notation, Figure 2.

Summation. The trained ear may also hear at the same time a summation tone which is very high, being represented by the sum of the two vibration frequencies, in this case 576 d. v. Titchener observes that: " Difference tones arc heard best with high-pitched generators, on account of their depth; summation-tones with low-pitched generators. Difference tones that fall below the octave C-c are, however, intrinsically so weak as to be heard with difficulty. They are plainest within the limits C-c″.

" As a general rule, generating tones (or relatively simple clangs) give better difference tones than generating clangs (or clangs rich in overtones). Tuning forks and blown bottles (stopped organ pipes, tubes), sounding at a moderate intensity, are therefore easier to work with than string or

[1] E. B. Titchener, "Experimental Psychology," *Student's Manual, Qualitative*, p. 40 ff., The Macmillan Co.

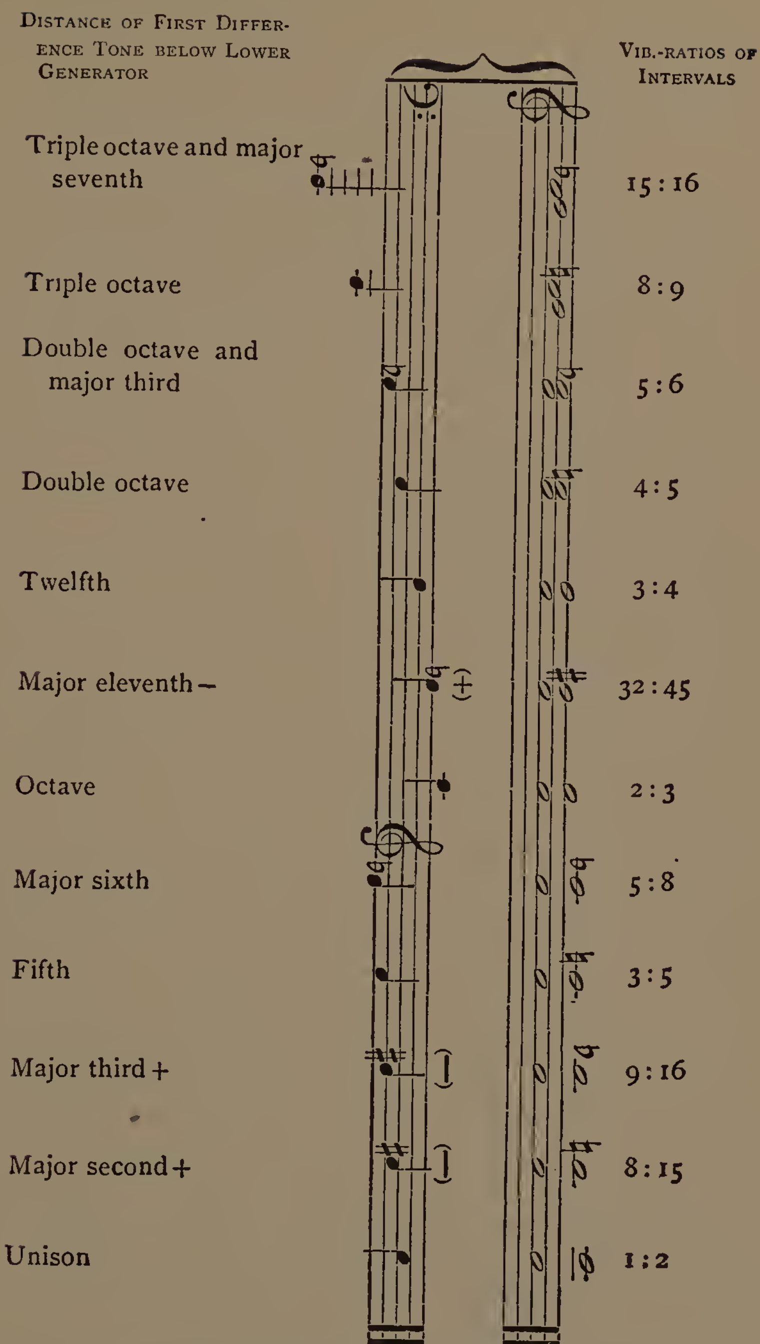


Fig. 1. — Illustrations of First Difference Tone. (Titchener.)

Distance of Second Difference Tone below Lower Generator	Vib.-ratios of Intervals
Minor second +	15 : 16
Major second +	8 : 9
Major third	5 : 6
Fourth	4 : 5
Fifth	3 : 4
Major sixth +	32 : 45
Octave	2 : 3
Octave and major third	5 : 8
Octave and fifth	3 : 5
Double octave and major second	9 : 16
Triple octave	8 : 15
[Tone absent: unison, 1 : 1, gives 1]	1 : 2

Fig. 2. — Illustrations of Second Difference Tone. (Titchener.)

reed instruments. The overtones of clangs generate difference tones of their own, which serve to distract attention from the difference tone of the fundamentals.

"In certain cases, however, the secondary difference tones may reënforce the primary difference tone. This happens with clangs of shrill, sharp, thin clang tint. Try with toy trumpet, double bicycle whistle, mouth organ, concertina."

Resulting complexes. Sizing up the situation, then, we realize that when two notes are sounded together, each note consists of a clang of fused overtones and each of these clangs produces a series of combination tones so that we hear not only the first of the two notes sounded, but we hear also a third note, which is quite distinct in pitch, and possibly a fourth or fifth. It therefore becomes a perplexing problem of harmony to deal with harmonic relations between these combination tones in addition to the actual notes so sounded.

II. Spatial Fusions

The principle of the telharmonium. On the other hand, any number of simultaneous tones of the same pitch will fuse into one, regardless of the direction from which they come. They will be heard as a single tone located not in any of the sources, but as a phantom sound in accordance with very definite laws of localization. This was well illustrated by the telharmonium, an electric organ, which, as first set up, had the keyboard two miles down town and the resonating horns, which produced the tones, scattered around on top of exhibit cases in all parts of the Museum of Natural History in New York City. Those who studied the situation will recall that, no matter how many horns of the same pitch there were, or how far apart they were located within hearing distance, they would all result in

one tone located somewhere in the building, the situation determined by the relative intensity and distance of all the component tones.

Many locations of a phantom sound. Our latest investigations prove that this resultant or phantom tone may have a considerable number of locations, each of which can be predicted with precision on the basis of wave phase relations. That is, the phantom sound shifts its position in a predictable way for different positions of the listener. Another expression of the same principle is the phenomenon that, for a given position of the listener, a phantom sound will move in a predictable course with variation in its pitch. When we combine three, four, or more notes into a chord, the complexity of the situation increases in geometric ratio.

Harmonic blends result in phantom sounds. The most important integrating tendency is, however, the tendency of two or more tones to fuse into one undifferentiated clang in the same manner as a harmonic series of overtones blends into a unitary, but rich tone.

Summary. Thus, when two violin tones are sounded together, we encounter, on the one hand, the fact of actual disintegration by considering overtones, and combination tones in addition to the two fundamental clangs; on the other hand, we integrate by accepting the fusion of overtones, the fusion of consonant tones, the unification of identical tones from various sources, and the tendency to neglect the combination tones because lacking in objectivity.

III. Nature of Consonance

Definition. The sense of consonance is the natural capacity for hearing differences in consonance and dissonance. It is the basic power that underlies the ability to

judge æsthetic effects in combinations of tones, as in harmony. It is, therefore, an index to precision in an æsthetic judgment of sensory impressions. We speak of consonance and dissonance with reference to two-clangs. A two-clang is consonant when the two tones tend to blend and to produce a relatively smooth and pure clang; and, conversely, a two-clang is dissonant when the two tones do not tend to blend to produce a relatively smooth and pure clang. We shall proceed on the assumption that there is a gradual transition from the purest consonance through the various semi-consonances and semi-dissonances to the worst dissonances.

Difference of opinion. If one turns to the mathematics, physics, physiology, psychology, or musical history of the concept of consonance, he meets with distressing ambiguities and contradictions. Within none of these fields is there a general agreement as to what consonance is. This explains the fact that different investigators come to different conclusions according as they proceed upon one assumption or another in regard to the nature of consonance.

Historical. Pythagoras introduced the theory of simple mathematical ratios which was later formulated by Euler into the law, "The degree of consonance is in direct ratio to the magnitude of the common divisor of vibration frequency." Schopenhauer maintained that, "music is a means of making rational and irrational relations of numbers comprehensible," not like arithmetic, by the concept, but by bringing them to a knowledge which is perfectly, directly, and simultaneously sensible. Consonances and dissonances, with their many kinds and innumerable degrees of variation, portray the differences of the human will in the essential fields of satisfaction and dissatisfaction. Helmholtz put the matter to experiment and concluded

that consonance is dependent upon the coincidences of upper partial tones which result in a relative absence of beats. He, therefore, made smoothness the criterion of consonance. To the overtones Tartini and Preyer added combination tones. Stumpf, taking the purely psychological point of view, made fusion the criterion of consonance: when two tones fuse into one they are consonant. Wundt[1] recognized, from the psychological point of view, four criteria of consonance: (1) purity, the number of primary difference tones of different orders, which combine to give the consonant chords a distinct or individual character; (2) uniformity, the uniform relation of the intervals to the compass of the scale; (3) the discrimination of consonance by the recognition of the tonal elements, dependent on the direct and indirect relation of clangs; (4) the fusion of tones into a "clang unity" through the dominance of one of the tonal elements — the one which arouses the most intensive associations.

Table I. It is evident that, with such diverse attitudes toward the conception of consonance, the ranking of consonances and dissonances should vary with different investigators. The historical data are summarized in Table I as given by Malmberg.[2] It will be observed that some of these do not admit of a serial order but limit themselves to five or six instead of twelve distinctions.

Reasons for disagreement. There are several reasons for the discrepancies. In the first place, we are not justified in classifying on a mathematical basis of simple ratios or a simple basis of overtones or combination tones, because it has been demonstrated that the phenomena which we call consonance do not conform to any such simple scheme.

[1] "Physiologische Psychologie," II, Leipzig, 1902.

[2] "The Perception of Consonance," Univ. of Iowa, Stud. in Psychol., 1918, VII.

TABLE I. HISTORICAL ORDER OF CONSONANCES AND DISSONANCES

AUTHORS	DATE	INSTRUMENT	METHOD	CRITERIA	1:2 c′c″	2:3 c′ g′	3:4 c′ f′	4:5 c′ e′	3:5 c′ a′	5:6 c′ e♭′	5:8 c′ a♭′	5:7 c′ g♭′	9:5 c′ b♭′	9:8 c′ d′	15:8 c′ b′	15:1 c′ d♭′
Franco of Cologne	Twelfth century		Theoretical	Pleasantness	1	2	2	3	4	3	4	5	5	5	5	5
Euler	1739		Mathematical	Pleasantness	1	2	3	4	5	6	7	8	9	10	11	12
Helmholtz	1863	Various	Coincidences of upper partial beats	Smoothness	1	2	3	5	4	6	7	8	9	8	10	11
Stumpf	1883	Pipe organ (different stops)	Analysis	Fusion	1	2	3	5	4	6	7	8	9	8	10	11
Faist	1897	Pipe organ (different stops)	1 } Direct	Fusion												
			2 } Analysis	Fusion	1	2	3	4	4	4	4	5	5	5	5	5
Meinong and Witasek	1897	Violin	Paired comparisons	Fusion	1	2	3	5	6	9	4	7	8	10		
Lipps	1899		Theoretical	Rhythmic coincidences	1	2	3	4	5	6	7	8	9	10	11	12
Buch	1900	Pipe organ	Analysis	Fusion	1	2	3	3	3	4	4	4		5	6	
		Tonmesser		Smoothness												
Krueger	1903	Tuning forks	Analysis	Purity	1	2	3	4	3	6	5	5	4	7		
Pear	1911	Tonmesser	Paired comparisons	Fusion	1	2	3	4	5	7	6		8	9	10	11

In the second place, up to the time of Wundt, the mistake was made of assuming that there was only one criterion, such as smoothness or fusion. But, in the third place, the fundamental source of error lies in the assumption that consonance is to be judged in terms of agreeableness; here we face the difficulty that what is agreeable to one is not agreeable to another, and what is agreeable to any individual at one time is not necessarily agreeable to him at another time.

Three criteria of consonance. We are forced, therefore, to define more precisely our conception of consonance by basing the decision upon a judgment rather than upon a feeling and to specify as the basis for this judgment the criteria which we find involved. As a result of experimental analysis we find these, tentatively, to be as follows:

For consonance:

1. Blending — a seeming to belong together, to agree.
2. Smoothness — relative freedom from beats.
3. Purity — resultant analogous to pure tone. (See Wundt.)

For dissonance:

1. Disagreement — incompatibility.
2. Roughness — harshness, unevenness or intermittence.
3. Richness — resultant analogous to rich tone.

On the basis of these criteria we derive the definition stated above: when the two tones of a two-clang tend to blend and produce a smooth and relatively pure clang they are said to be consonant. Dissonance is the converse of this.

Agreeableness and disagreeableness. In addition to the above three criteria, restfulness, a feeling of completeness, finality or satisfaction with its opposite, disquietude, a feeling of needing to be resolved, has been thought to be a fourth criterion; but this must be eliminated on the ground that it is a variable, affective criterion, due to progression and association and other variable factors of harmonic

value. In asking whether a two-clang is consonant or dissonant, therefore, we do not ask if it gives an agreeable or disagreeable feeling, or which is the more agreeable or satisfying, but we require an æsthetic judgment in terms of the three specified criteria. In so doing, we do not ignore feeling; we simply limit ourselves to those conditions of agreeableness or disagreeableness which are constant or inherent in the isolated two-clangs, in such a way that they can be repeated under control.

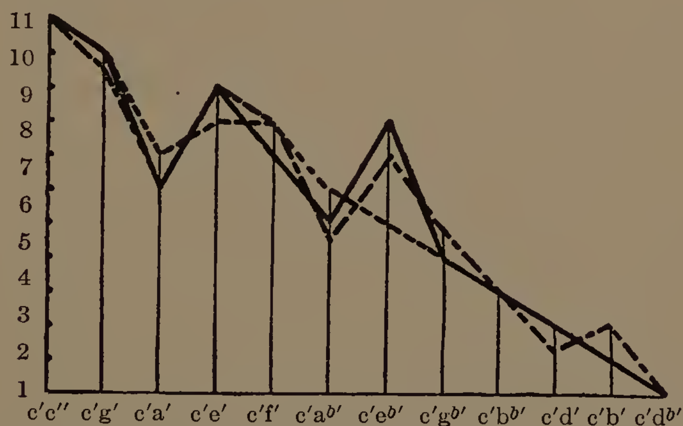


Fig. 3. — Consonance-dissonance Rank in Terms of Blending.

The numbers at the left express the relative preference for each two-clang in terms of the number of other two-clangs to which it is preferred.

Notation: Piano: ————
Fork: - - - - - -
Organ: —— - ——

Figures 3 to 6. Working with trained observers in conference for a long period of time, on the basis of these criteria, Malmberg[1] established the order for the piano (tempered scale), pipe organ (stopped diapason), and tuning forks before resonators (pure tones in just intonation). Figures 3, 4, and 5 show the order of rank of each interval within the octave on the three criteria, blending, smoothness, and purity.

[1] *Op. cit.*

Effect of timbre. These data show that the order of rank varies with different instruments, that is, for differences

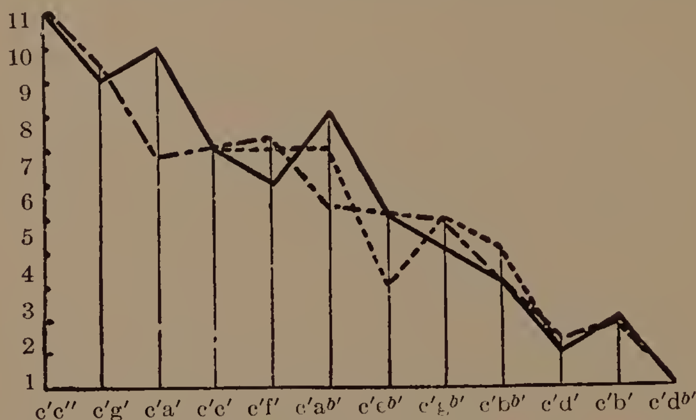


Fig. 4. — **Consonance-dissonance Rank in Terms of Smoothness.**
Notation same as in Figure 3.

in timbre, so that slightly different norms will be needed for different instruments.

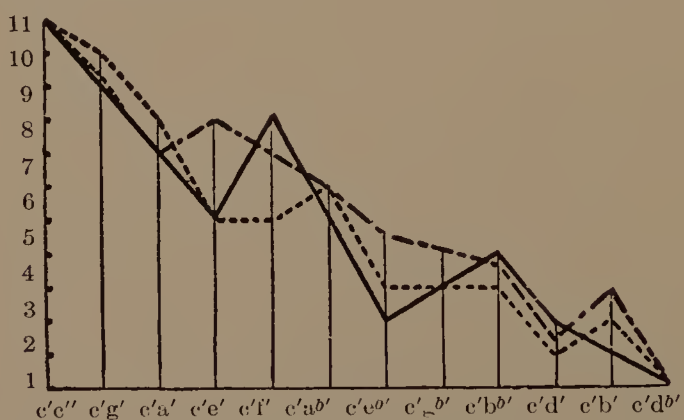


Fig. 5. — **Consonance-dissonance Rank in Terms of Purity.**
Notation same as in Figure 3.

Effect of tempered scale. A comparison of pure tones in the tempered scale with those in just intonation showed that these differences did not alter the rank of any intervals, although it did result in appreciable differences in the degree of consonance.

Variation with criteria. The order is materially different for different criteria, and this difficulty we must meet in some effective way; because, in order to deal with consonance-dissonance as a whole, it is necessary to take into account at least these three criteria.

Fusion. As Malmberg[1] demonstrated, the ranking on Stumpf's criterion, fusion, does not agree with the ranking in the three criteria here adopted. We leave it out of account because, in so far as fusion means more than "blending," it represents the factor of "unanalyzability" which, in some cases, contradicts the other criteria; c d♭, for example, ranks high in fusion, but low on smoothness or blending.

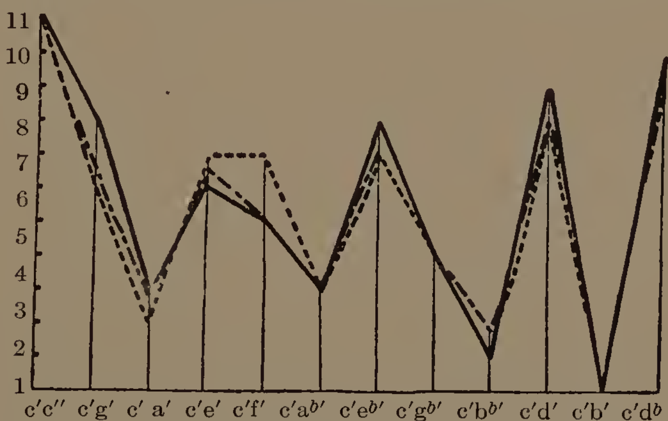


Fig. 6. — **Consonance-dissonance Rank in Terms of Fusion.**
Notation same as in Figure 3.

Coöperation of criteria. We find that some intervals are judged predominantly on one of these criteria, and some on another. It is possible to base a decision primarily on a single criterion, the appropriate one in each case, by observing the following rule: "Give the decision on blending alone if the degree of blending is perceptibly different; if not, make the decision on smoothness; and, if there is no dif-

[1] *Loc. cit.*

ference in either smoothness or blending, base the decision on purity." Table II indicates the characteristic basis of

TABLE II. BASIS OF JUDGMENT FOR INDIVIDUAL PAIRS

	c' g♭'	c' d♭'	c' f'	c' d'	c' e'	c' e♭'	c' g'	c' c''	c' a♭'	c' b'	c' a'
c'd♭'	s										
c'f'	b	s									
c'd'	s	s	s								
c'e'	b	s	p	s							
c'e♭'	b	s	p	s	p						
c'g'	b	s	b	s	s	s					
c'c''	b	s	b	s	p	p	b				
c'a♭'	s	s	b	s	b	s	b	b			
c'b'	b	s	b	b	b	b	b	b	b		
c'a'	s	s	s	s	s	s	b	b	s	b	
c'b♭'	b	s	b	s	b	b	b	b	s	b	s

NOTATION: b, blending; p, purity; s, smoothness.

judgment for all the possible combinations of notes within the octave in such a procedure.

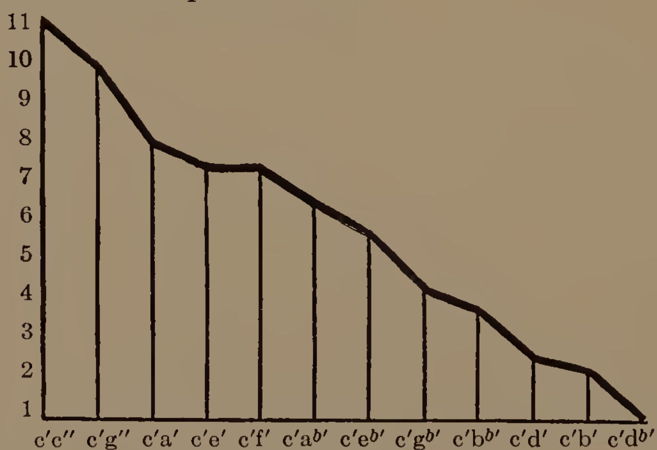


Fig. 7. — The Norm for Rank of Consonance and Dissonance. Notation same as in Figure 3.

The norm. Taking the above and other essential factors into consideration, we obtain Figure 7 as a practical standard for the order of consonance-dissonance with the piano, well tuned in tempered scale.

Stumpf's laws. The two-clangs here selected lie within

the range of c′-c″. How the order of preference would vary above and below the middle octave, within which most of our notes fall, remains to be determined. Stumpf and his followers have worked out certain laws in terms of consonance defined primarily as fusion, *i.e.*, the inability to say whether one or two notes were sounded. Although we cannot assume that they would hold for our conception of consonance, it is quite probable that some of them may. Among them are the following:

1. "Fusion depends on the so-called ratio of vibrations."
2. "The degrees of fusion are independent of the tonal region within the tonal range."
3. "The degree of fusion is independent of the intensity, whether indeed it be the absolute or relative intensity, so long as the tones remain distinguishable."
4. "The degree of fusion is not influenced by the addition of a third or fourth tone."
5. "Minimal deviations of the number of vibrations from the ratio create no perceptible difference in the degree of fusion. If the deviation be increased, the fusion in all pairs of tones, except the lowest degrees, passes into this degree without running through the intermediate degrees, if any. The rapidity of this transition is proportional to the degree of the initial fusion."
6. "Fusion remains and retains its degree when the two tones do not affect the same ear."
7. "Fusion remains in the mere representation of the imagination."
8. "If we proceed above the octave, the same degrees of fusion recur with the ratio of vibrations increased one or more octaves."[1]

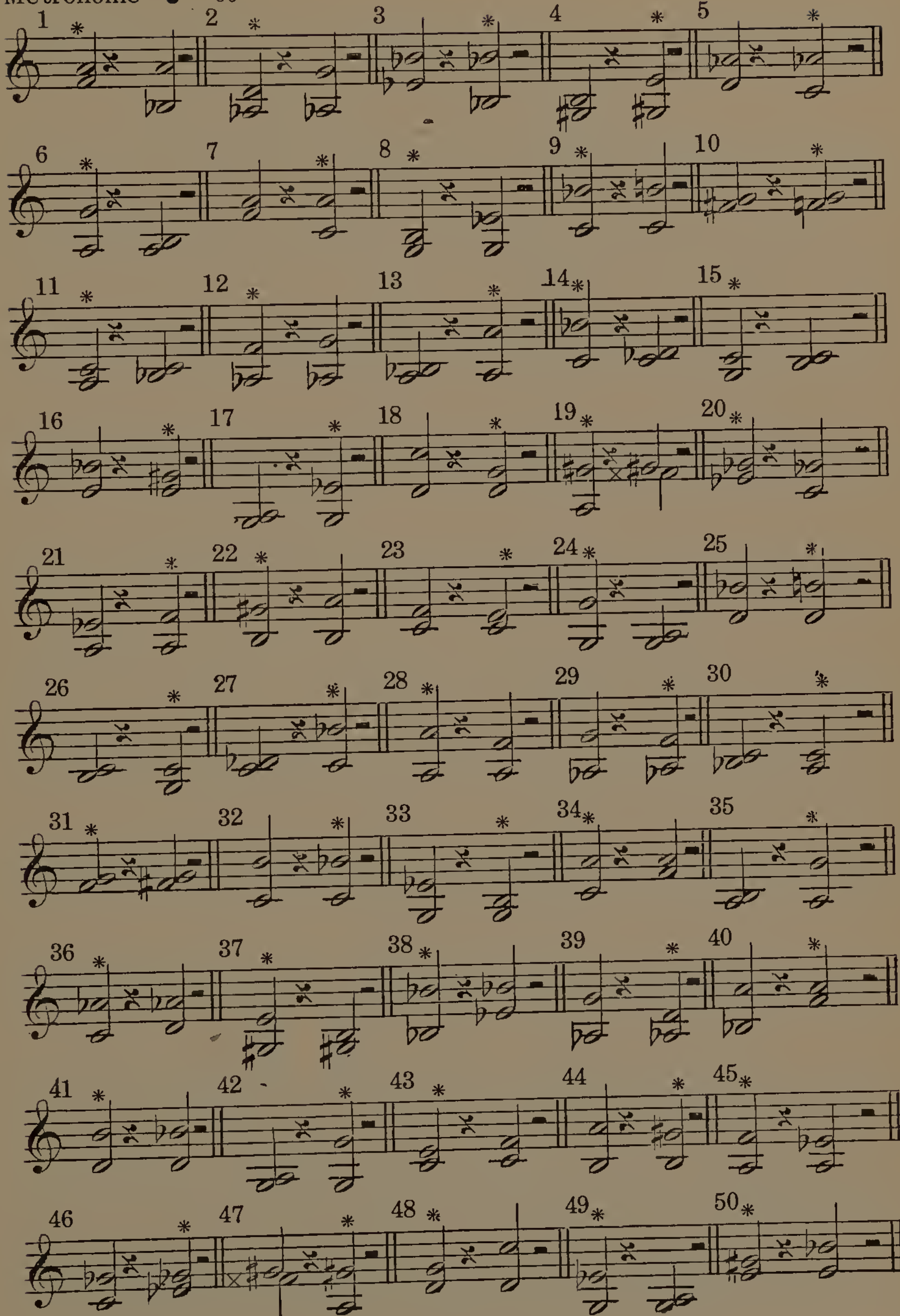
[1] "Tonpsychologie," Hirtzel, Leipzig, 1883.

IV. Measurement of the Sense of Consonance

Procedure. If we grant that this order of ranking from consonance to dissonance is in accord with the definition of consonance, we may use that as a norm in testing abilities in the sense of consonance. Various methods have been employed. One is known as the method of paired comparison. We take all intervals from c′ to c″ and compare each one with every other, requiring in each case that the decision be made as to which is the better consonance (or less dissonance) according to the definition stated above. The observer is drilled on the analysis of this definition and illustrations are given freely from combinations not to be used. There are sixty-six combinations. For a single group test these should be repeated about four times. The record may then be kept in terms of the per cent of right judgments, which may be reduced to percentile rank.

Precaution. The validity of these tests depends very greatly upon the precision and effectiveness with which the conductor states the basis of judgment, and it must be remembered that the norm here given must not be confused with various norms which may be recognized for harmonic values in musical progressions. With such we are not here concerned. Our object here is to evaluate the capacity for judging the characteristics of tone clangs quite apart from the knowledge of the laws of music or training in music. Since so much depends upon understanding the definition of consonance, this test must be handled with caution — for children, because they may not understand, and with musically trained persons, because it is difficult for them to lay aside the known functional laws of harmony.

Metronome ♩= 60



A shorter test. These sixty-six pairs are, however, of different values for rating purposes. We have, therefore, carefully analyzed the characteristics of each pair of two-clangs, both theoretically and in various actual experiments,[1] and have selected, from the total number, the twenty-five which are most advantageous for our purpose. They represent the eleven degrees of difficulty in judgment, as well as the main varieties involved, and are so varied as to break the monotony of using one note, c′, in all the two-clangs. The testing material thus selected is here presented

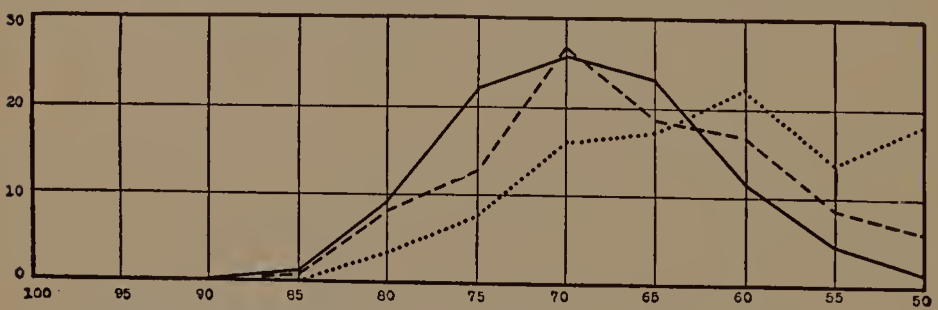


Fig. 8. — Distribution of Capacities for the Sense of Consonance.
Based on phonograph record Number A7539. Notation same as in Figure 6, Chapter II.

in musical notation; the starred clang is the one to be preferred. The listener is required to record in a prepared blank, b. for better, or w. for worse; always referring to the second two-clang as compared with the first. To make the tests reliable it is necessary to repeat. For this purpose it is suggested that, for a second series, the same material be played backward. This will then make one hundred trials which is adequate for purposes of general testing.

The distribution for this shorter test is here given in Figure 8, and the norms in Figure 9.

[1] Esther Allen Gaw, Univ. of Iowa, Stud. in Psychol., Vol. VII.

V. Relation to Age, Intelligence, and Training

Age. It was rather surprising in our first experiments to find how largely elemental this test is; that is, to what extent it embodies a simple direct judgment which is devel-

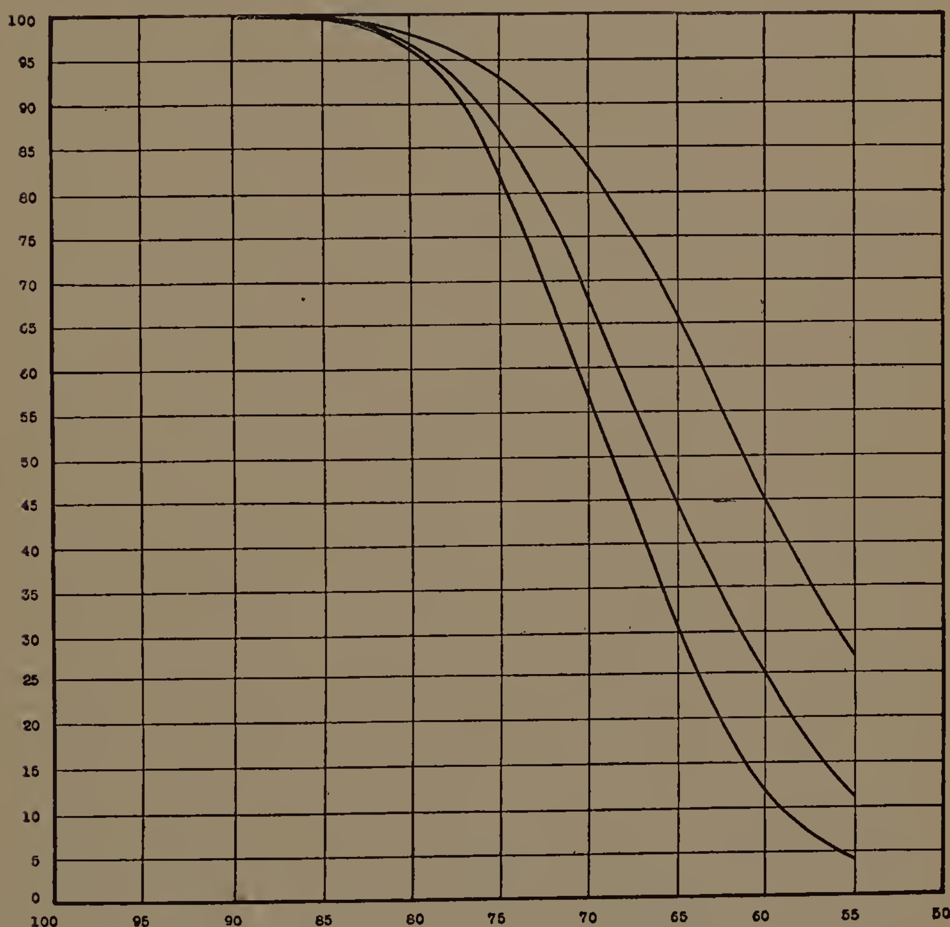


Fig. 9. — Norms for Converting Per Cent Right into Rank.

oped early in childhood outside of specific training. The "sense of harmony," which we have defined here more accurately as the sense of consonance, is undoubtedly a specific talent which one may have quite apart from special

education or keen intelligence very early in childhood. The difference in the abilities of children and adults as shown in these figures in a group test is really not more than what would be accounted for by the ordinary advantages under which a child takes a test as compared with an adult.

Training. Training undoubtedly favors improvement in the capacity here tested, yet not to any such extent as is ordinarily supposed. As in the capacities before tested, the child probably very early develops through practice in ordinary play and other activities the ability to notice differences in clangs. At any rate, it is astonishing to see how a small child, even without musical education, will show great keenness in this test and how among very intelligent adults one often finds incapacity for this test.

Intelligence. Since this is a test of ability in a specific judgment, it is an intelligence test; but it is interesting to find that, as in the case of the sense of intensity, it cannot be regarded as an index to general intelligence, such as is shown, for example, in the ability to do school work. Ability to judge consonance requires a certain degree of general intelligence not always found among children, and this results in a low rating of very dull children in consonance. But the sense of consonance is a gift which reveals itself, like the sense of pitch or the sense of rhythm, very early in childhood.

Consonance ultimately feeling. To child and adult alike, this does not take the form of a judgment in the spontaneous listening to music. It comes rather as a feeling of like or dislike. We must not minimize the rôle of feeling, sentiment, and emotion in the "enjoyment" of consonance and the "jarring" of dissonance. Harmony is and should always be experienced in terms of agreeable-

ness or satisfaction. But for psychological purposes it is quite possible to analyze any agreeableness and identify what it is that makes it agreeable. If one likes a certain kind of beefsteak, poetry, or landscape, it is quite possible to take a cognitive attitude toward this and state that a beefsteak with stated qualities, a poem with stated qualities, or a landscape with stated qualities, will arouse in him a feeling of agreeableness. Such is the course we have here followed in the treatment of this affective element of music. We have analyzed situations which are admittedly agreeable and devised a method of identifying such situations by the recognized marks, namely, blending, smoothness, and purity.

Guidance. The experimental results show clearly that if we make allowance as indicated in the norms for group tests, this sense of consonance may be tested early enough for guidance in music before the child knows anything about the musical theory involved or has had musical education. Here is then perhaps one of the important factors of what we call ear-mindedness.

CHAPTER VIII

AUDITORY SPACE

I. The Problem

Is hearing a spatial sense? If so, is there an original space attribute in hearing? How do we locate sounds by hearing? What is the nature of tonal volume? These are all mooted questions in current psychology. A fair discussion of them would require a large volume. But since space relations play but a secondary part in the rating of musical talent we may restrict this chapter to the merest summary statement of our present view of the situation in the light of a mass of conflicting data and theories. We must also refrain from entering upon the large problem of the function of space relations in musical æsthetics.

II. The Sense of Direction

Hearing direction. Auditory space presents three aspects: direction, distance, and volume. It does not involve true perception of form or relief. The hearing of distance is merely a judgment on the basis of intensity and timbre in the light of a general acquaintance with the relations of the source. Volume, as heard, is an immediate realistic experience quite devoid of the exact detail which is characteristic of volume as seen or felt in touch. The hearing of direction is the one rigid space function of the ear. We can hear the direction of a source of sound with considerable

precision, quite apart from the use of other senses. As in vision we have two eyes for the purpose of seeing distance, so in hearing we have two ears for the purpose of hearing direction. In addition to these we have two other space mechanisms in the ear: the funnels of each ear and the corrugations in the walls of these funnels.

Binaural intensity. The intensity of the sound differs in the two ears according as it falls more directly into one ear than into the other. We have thus come to interpret intensity in the two ears as meaning difference in direction.

Laws of localization. The delicacy of the hearing of direction varies in accordance with some very interesting laws for the various directions from the center of the head. If, for example, sounds are produced in the median plane, *i.e.*, a plane through the center of the head, at right angles to the aural axis, it is impossible to distinguish in these front from back, up from down, or any other radial direction within that plane; but right and left deviation from that plane can be heard with accuracy down to a single degree of deflection. This is direct proof of the principle of binaural intensity: the sound is of equal intensity in the two ears for all directions within the median plane; but a slight shift to the right or to the left from that plane results in a distinct change in the binaural ratio of intensity.

The relative accuracy for all other positions has been measured, platted on charts, and expressed in definite laws.[1]

Monaural intensity. But a person with one ear can hear direction with surprising effectiveness. This is done partly in terms of the difference of the intensity of the sound which is determined by the directness with which the sound waves

[1] For a brief survey of auditory space, see the authors' manual "Elementary Experiments in Psychology," Ch. V. (Henry Holt & Co.)

enter the funnel of the good ear; the more directly the waves impinge upon the ear drum, the more intense the sound will be; shadow of the head and reflection from the walls of the funnel weaken it.

Monaural timbre. Sound also changes its timbre in accordance with the direction from which it impinges upon the ear. The ledges, grooves, and curvatures of the outer ear break up the sound, taking out certain overtones and reënforcing others in accordance with the direction from which the sound waves strike.

The long ear and the human ear. There are two kinds of ears for the hearing of direction; one is a long funnel, such as that of the rabbit or the horse. This is movable and aids the hearing of direction through change of intensity by means of motion. The other type is that of the human ear, which works on an entirely different principle, the principle of timbre. The human ear is not, as is generally supposed, a degeneration from the long ear and therefore less efficient. Nature had two means at disposal and tried both: the long ear in the higher animals, and the corrugated chiefly in man. The latter is undoubtedly superior.

Wave phase. Extremely interesting laws of the localization of sound, in terms of wave phase, have been worked out in recent years. It is a significant thing that most of the work on this subject was done as purely theoretical work without any intention or knowledge of practical utilization. Indeed, the work was not only purely theoretical, but it had to do with an illusion, a phantom sound, a sound that seemed to be where it was not. Yet, when the submarine menace appeared, the scientists found in this illusion a most serviceable tool, for it was by means of the knowledge of the laws of this illusion that we were able to locate

the submarine. Thus, from being the object of pure scientific curiosity, the location of sound by means of wave phase became a most valuable instrument for the protection of life and property in the great war.

The use of an illusion. In this connection it is also of interest to note that, in selecting listeners who were to use these instruments in locating the submarines, it was found that ability depended largely upon the possession of a musical ear. It is safe to say that, of the intelligent candidates who presented themselves for this branch of the service, it was possible to pick out, by psychological methods, some who should be more than ten times as capable as others in guarding life and property, by this instrument. Thus the antipodes meet — in music and warfare.

Wave phase interpreted in terms of intensity. But the treatment of the rôle of wave phase in auditory perception of space must constitute a volume in itself. Suffice it to say that the experiments now in progress have demonstrated that all the phenomena of wave phase can probably be interpreted in terms of the intensity of sound.

III. The Sense of Extensity

The experience of extensity. If, on a clear day, we look up into the sky above the horizon with eyes still and wide open, we see no form, or movement, or distance, but simply get one vast impression of undifferentiated bigness or extensity. So in hearing, if we listen, for example, to the keys of the piano played in succession from the highest to the lowest without any reference to the source of the sound, its mode of production, or its meaning, we get an impression of increasing bigness or extensity from the highest to the lowest tone. It is a purely sensory matter quite

independent of interpretation. Indeed, some claim that we distinguish tones quite as much by their extensity as by their pitch.

Extensity the spatial attribute of sound. Many distinguished psychologists doubt the existence of this attribute of sound. We are, however, at present inclined to believe that there is such a factor: entirely apart from association of other senses or with intensity, timbre, or duration there is, in the hearing of all tones, an inalienable experience of bigness. This bigness varies directly with pitch. The high tone is heard as small, piercing, and thin; whereas the low tone is heard as large, massive, rolling, or at least blunt.

Correlated with pitch; hence no separate rating needed. Extensity varies exactly parallel with pitch; there is an inseparable duality. Physically and physiologically both pitch and extensity depend absolutely upon the wave length, and may be expressed in exactly the same terms; but psychologically the two are distinguishable. One experience is tonal, pitch; the other is spatial, extensity. For the purpose of rating talent it is, therefore, unnecessary to concern ourselves with the isolation of the sense of extensity.

Important factor in music. With some training it is quite possible to isolate the two so as to ignore pitch and measure sound discrimination in terms of extensity, quite as above we ignored extensity and measured discrimination in terms of pitch. Indeed, in music, we are often in the attitude of appreciating massiveness, bridging-power, and expansiveness of low tones, and concentration, isolation, and penetrating-power of high tones quite as much as pitch.

Further limitations. Likewise, we are not here concerned with the theory of how the awareness of extensity is built

up through association with intensity and timbre into the perception of direction and other spatial dimensions in hearing, as those considerations do not directly affect the evaluation of talent.

IV. The Sense of Volume

Volume a complex. The term "volume," as ordinarily used, does not represent a single attribute of sound, but rather combinations, among which the following are perhaps the essential components:

Extensity. Tones are small or large according as they are high or low, as described above. Therefore, to get a large volume in musical effects we choose the low tones. This does not result in loudness, but bigness. The intensity, or loudness, in the sense of intensity, may be the same for a high tone and a low tone, and yet the low tone is invariably bigger than the high tone. It has a different body. This body is not necessarily thought of as having any particular shape, relief, or position; it is merely the immediate and unmistakable awareness of undifferentiated bigness. Usually we image and think of it in terms of the known source, such as the horn or the string — the little horn or the big horn, the short string or the long string — but that is a secondary matter and not essential to the experience of extensity.

Intensity. Volume may also be expressed in terms of intensity. If we take two tuning forks an octave apart, the difference in the extensity of tones is fixed, being rigidly parallel with pitch; but we may easily strike them so as to give equal intensity; so also we may vary the intensity in any degree without affecting the extensity. Conventionally, we often speak of more or less volume, when actu-

ally we refer to intensity only; therefore, to secure this kind of volume, we make the tones intense.

Timbre. Volume is also thought of in terms of richness or timbre. The sound of middle C on the piano, for example, is more voluminous, richer, fuller, than the pure tone of a tuning fork of the same pitch; therefore, to get this kind of volume we produce rich tones rather than thin or pure tones. Richness is favored by low tones; therefore, by using low tones, we may get volume in extensity, richness, and intensity combined.

Reduplication and reflection. The rapid repetition or simultaneous sounding of several tones or tone elements, as in band music, a strong crash, or a roar, gives the effect of volume. The same result is produced in reflection; the more intense a sound is, the more likely it is to reverberate from the larger number of angles in surrounding walls and spaces and literally impinge upon the ear from different sources. That increase of volume also changes intensity is illustrated, for example, by the fact that the cheering of the crowd at a football game can be heard at a much greater distance than the wildest cheering of a single person can be heard.

Analysis of volume an aid to precision and description. Volume, then, may be of radically different kinds, such as extensity-volume, intensity-volume, timbre-volume, and a duplication-volume. These different kinds may combine into countless complexes. Yet there is no excuse for vagueness in language and looseness of interpretation; for the critical evaluation and description of volume in music may be founded upon a clear concept of the components of volume.

Significance for music. In view of the above analysis,

it is evident that the sense of volume does not call for one specific measurement in our rating for musical talent, as do pitch and time. It must be rated in terms of the component factors: the sense of extensity, the sense of intensity, and the sense of timbre; perhaps the most representative among these is the sense of intensity. Although not rated separately as a talent, the sense of volume is a most vital concept in music. Like the play with rhythm, the manipulation of volume is one of the prime factors at which musicians aim.

CHAPTER IX

VOLUNTARY MOTOR CONTROL

I. Introduction

Motor capacities correspond to the sensory. We found in our discussion of hearing that the mental capacities or talents correspond to the attributes of physical sounds, namely, pitch, intensity, time, and extensity; so we shall find in musical action the necessity of motor control for each of these attributes, particularly, the capacity for producing and controlling pitch, intensity, and time respectively. For the present purpose we may regard extensity as absorbed in pitch. In addition to these three basic capacities for action, we must also trace more complex abilities which operate in the expression of sound complexes, namely, the capacity for rendering and controlling timbre, rhythm, consonance, and volume of tones. Since musical action is more or less a result of special training and, since we desire to rate natural capacity before musical training is begun, we must analyze the required types of action and trace briefly the fundamental capacities which may be isolated and studied under control.

Basic motor capacities. The analysis here to be made is one which finds application to many other occupations besides the study and practice of music. Indeed, we shall deal with a basic series of tests which may furnish some fundamental information that may be of service in guiding

a person into any occupation which requires skill in motor control.

The personal equation in action. It is well known that persons differ in their natural power of action, and educators are beginning to recognize that traits which may be discovered early in childhood remain fairly constant into old age except when these differences are due to acute disease or temporary injury. Thus, we find among children those who are slow and sure, slow and erratic, quick and sure, quick and erratic; and no one seriously expects these tendencies to be altered any more than he expects the leopard to change his spots. These permanent peculiarities we call the personal equation. Such differences might be enumerated at great length, but let us look rather for a basis of classification which may serve our purpose. Such a classification must take into account speed, accuracy, strength, endurance, uniformity, reliability, and other factors; and it must isolate various types of intellectual control embracing mere movement, response to a simple signal, the expression of a judgment, and the application to a continuous work. The essential facts may, perhaps, be most conveniently set forth in the following items:

I. Time
   1. Motility
   2. Timed action
   3. Response to simple signal
   4. Action upon choice
   5. Serial action

II. Movement
   1. Precision
   2. Discrimination
   3. Strength and endurance

Elemental factors. These capacities in their vast series of ramifications condition the rendering of pitch, time, intensity, timbre, rhythm, consonance, and volume of tones both vocal and instrumental. In all the tests herein described an effort is made to reduce the action to the very simplest form of its kind, and to avoid using any particular action which is the result of specific training. In so far as we succeed in this, the test will be equally fair, within reasonable limits, to trained and untrained, to bright and dull, to young and old. Both quantity and quality of achievement must be considered.

II. A Chronograph and a Chronoscope

The chronograph. The apparatus shown in Figure 1, Chapter II, may be converted into a chronograph which is adapted for the measuring of various aspects of time in action. An electro-magnetic marker is mounted in place of the tuning fork on the endless screw. This marker consists of a magnet carrying a fountain pen which writes on a sheet of white paper revolving on the phonograph disk. The signals and responses are registered in the form of a jog in the tracing from the fountain pen. The magnet operating the pen is placed in the circuit with signaling devices and response devices. By turning the endless screw, the pen may be turned in or out at any desired rate or spacing. By means of a trigger key, the signals are all given at the same point in the revolution of the disk. This point is indicated by a straight radial line across the disk, made by drawing the pen from the center to the outer edge of the record when the disk is at the exact stage of the revolution at which the signals are given. The pen runs idle except when the trigger key is held down, thereby saving space on the paper. This

simplifies reading by having the readings all start from the same point. When the record is to be read it is laid on a circular scale projecting beyond the edge of the disk and divided into a hundred units. The radial line is laid over zero on the scale (making allowance for the latent time of the magnet, .006 sec., once for all, in this setting). A pointer, pivoted at the center of the disk, is then laid over the record as a guide. When the edge of the pointer lies over the recording jog in the record, it points to the reading on the scale in terms of one hundredth of a revolution. If the disk is revolving at the rate of one revolution per second, the unit will be .01 sec. If it is run at any other speed the record may be converted into one-hundredths of a second by multiplying the final average of the records by the ratio of the actual speed to the speed of one revolution per second.

The phonograph as a motor. This chronograph consists of certain accessories which may be mounted on any good phonograph of the disk type without dismantling or interfering with its use in the playing of records. The accuracy of the measurement depends, of course, primarily upon the accuracy of the speed of the phonograph disk. Measurements upon the principal makes of instruments show that, when a machine of one of the standard makes, in good condition, is run within its normal range of speed, wound to a moderate tension, and kept in good condition, it runs with an error of less than one thousandth of a second, as is shown graphically in the frontispiece. The close conformity of the waves indicates the high degree of accuracy. Each wave denotes .01 sec. A deviation of .001 sec. in a revolution would, therefore, show in a discrepancy of one tenth of a wave in two successive revolutions. This record was

made by recording, by means of a delicate marker, the vibrations of a 100 d. v. tuning fork on a sensitive plate revolving on the phonograph disk.

The chronoscope. For many purposes the chronoscope shown in Figure 1 is better than the chronograph because the time of the act is shown instantly on the dial, as on a clock,

Fig. 1. — The Phonograph Chronoscope.

doing away with the graphic records. The chronoscope consists essentially of a dial and two magnets with a small portable tripod for support, which may be set up on any good phonograph of the disk type. The lower magnet rests on the phonograph plate and revolves with it. The upper magnet is mounted on the dial and remains stationary. The pointer is swung in delicate adjustment between the two

magnets, so that when the current is sent through the lower magnet the pointer is picked up by this magnet and turns with the disk until the current is shifted to the upper magnet when it adheres to that magnet and remains stationary pointing at the desired reading on the scale. For each measurement, we set the pointer at zero on the scale; the giving of the signal starts it to revolve with the disk and the response stops it at the number on the scale which indicates the number of hundredths of a second between the signal and the response.

III. Motility

Simple method of testing. Motility, or motor ability, as it is generally called, is the name given to tests of maximum speed in elemental forms of movement. This may be tested roughly in a class by requiring each pupil to take a pencil in hand and tap with it on a pad of paper as fast as possible to find how many taps he can make in five seconds. The hand must be allowed to move freely so that the dots may be counted. Some preliminary instructions should be given as to the importance of making small movements with maximum speed, and a few preliminary trials should not be counted. The number of dots made in five seconds by children of the age of ten will vary from twenty to sixty, and the significant thing is that the number will tend to be fairly constant. The child tends to remain in the twenty class or the fifty class, according as he finds himself in one or the other after the preliminary trials, and these differences are likely to characterize the rate of movement of the respective individuals throughout life.

Interpretation in daily life. It is extremely interesting to take a simple record of this sort and to interpret the work

and play of the child in such terms, noticing how this fact of slow, average, or quick motility not only accounts, in large part, for his achievements in work and play, but also serves as a key to his interests, his ambitions, and in many respects to his feelings and sentiments with reference to his environment.

Exact measurement. For exact measurement of motility, we use the chronograph, as described. The subject is required to grasp a telegraph key with the thumb and the tips of the first two fingers and to hold the entire arm in free suspense under tension, leaning his body forward and in this position to tap as fast as possible with the key. Very careful guard is kept over the subject as to position, attitude of tension and attention. Ample practice is given to familiarize him with the simple movement, and the record is taken for eight seconds only. This tapping is recorded by the pen on the chronograph; the time taken for each tapping movement is thus recorded in terms of hundredths of a second. We compute the average and mean variation.

Two factors: speed and regularity. There are thus two factors in this record which are really separate. One is speed (average time) and the other is the regularity (mean variation). If we emphasized regularity in the instructions, the result would be a slowing down of the speed. We therefore throw the idea of regularity into the background and make the test primarily a trial of speed. It would be worth while to make a separate trial for accuracy in which speed would not be emphasized, but for most purposes the variability shown in the test, as here given, is a serviceable measure of regularity.

Applies to all muscular movement. This principle of measurement may be applied to the movement of any

muscle in the body, for example, the lips, a toe, a wrist. It has not yet been fully determined, but it seems probable that we shall find a general relationship in the motility of all the various voluntary muscles of the body. That is what we imply when we say one is quick and erratic, slow but sure, slow and reliable, etc. We assume that it does not make much difference whether you test on one muscle or another; the condition seems to be a central one.

Significance of this. If accurate measurement now in progress should substantiate this view, it would mean much for vocational guidance, particularly in music. Under this hypothesis we might have our motility measured on any simple movement which lends itself conveniently to accurate measurement and transfer that record under certain conditions to other movements supposedly under the same central control in general. Doubtless we should find exceptions; but the general plan is promising. The record of speed in tapping might be regarded as an index to the motility in finger movement on a given instrument or even an index to motility in speech or singing. Indeed, it is a common observation that the child who has good control of his feet and fingers also has good control of his voice.

IV. Timed Action

Two forms. Timed action may be measured by determining the average error in keeping time with a set standard, or by measuring average error in uniformity, in free marking of time. The former we call regulated timed action, and the latter free timed action. The two may be measured with the same apparatus and at the same sitting.

Regulated action. The standard time is set up by having a telephone receiver so connected with a contact on the

chronograph that a click is produced in the telephone receiver once for each revolution of the phonograph disk. The person tested is then required to keep exact time with the sound he hears by tapping with the telephone key so that the click of the key shall synchronize with the click in the telephone receiver. The telegraph key is so connected with the fountain pen marker on the chronograph that a jog in the tracing line is made at the moment the telegraph key is tapped. A base line is set up by sliding the recording pen from the center to the outer edge at that point on the disk at which the contact produces the telephone click. If then the time is marked accurately, every jog in the tracing marking the tapping of the key should occur exactly on this base line. Deviation from this base line is recorded in thousandths of a second as the measure of the error in keeping time. Usually the chronograph is so set that it beats time in exact seconds. From a number of records we may compute the average and the mean variation, showing characteristic tendency, frequency, and the average amount of anticipation or lag.

Free action. This is historically, but erroneously, known as free rhythm. To measure it we use the same procedure as for regulated action except that, after the person to be tested has heard the time for about ten seconds, the telephone circuit is broken and he is required to mark the time by himself, the record being made as before. In this case, however, we measure, not the deviation from the standard, but the deviation from the average of the actual performance, the time of each act being recorded in terms of the time scale as described above. The particular time of the second beat is suggested in order to make records of different persons in terms of approximately equal intervals and simplify

the reading on the chronograph; because, to the extent that the time is kept accurately, the records will occur on one radius and the reading can be made almost instantaneously.

Conditions of capacity. Failure in this test may be of different kinds and due to different causes. It may be due to the sensory defect; ordinarily we should never look for a record in action to excel the record in the hearing of time. It may be due to lack of muscular control which may be of two kinds, either a nervous irregularity or an inadequate association between the sense of time and movement. If a person with a good sense of time makes a good record in action, all is well. If a person with a poor record in sense of time makes a poor record in time, the cause may lie either on the sensory or the motor side, or both. If a person with a good sense of time makes a poor record, the source of trouble is on the motor side. Of motor defects involving this act there are numerous kinds, but analysis of these would take us too far into detail.

V. Simple Reaction Time

Reaction, simple and complex. Simple reaction time is the time that it takes to make a simple response to a simple signal. Signals may, of course, be of thousands of varieties and so may also the responses; but, as in motility, it is possible to select some typical signals with simplest possible responses, both of which can be well controlled for the purpose of measurement. Reaction time experiments may be divided into two large groups: first, simple reaction which is the barest sensation-movement response; and, second, complex reaction involving some form of the higher mental processes.

Measurement of simple reaction. For our purpose the following well-known form of the simple reaction is the

most serviceable. The observer hears a sound signal in a telephone receiver and responds by the simplest finger movement. The time between the signal and the response is measured in hundredths or thousandths of a second. This measurement may be made with our chronograph as follows. A telegraph key is placed in a circuit with the trigger key, so that when the base line on the record passes the trigger, a sound will be made in the telephone. The response to this sound is the pressing of the telegraph key under the most favorable conditions.

As stated in the description of the apparatus, all the signals will occur along one straight line which can be drawn from the center of the disk to a certain point on the trigger; and the response to the pressing of the key is recorded by a jog in the pen tracing so that, when the base line is set at 0 on the scale, the time of each reaction may be read by running the time lever to the jog in each successive tracing and noting the reading on the scale. The test may be made more quickly by the phonograph chronoscope.

Two measures, time and reliability. Here again we get two measures: first, the average or median reaction time; and, second, a measure of the reliability or regularity in terms of the mean variation calculated, as shown in Chapter III. These two measures will range from the extremely quick to the extremely slow in the one series, and from the extremely reliable and uniform to the extremely unreliable and erratic. Records in terms of these two measures become striking pictures of personal equation. The single statement, for example, that this person has an average reaction time of .11 sec. with a mean variation of .01 sec. marks him as having distinctly superior power both in speed and accuracy, whereas a person with an average reaction time of .25 sec. and

a mean variation of .10 sec. is equally well marked as quite helpless in this capacity. Between such extremes we have all gradations and combinations of speed and accuracy which express this type of motor power quantitatively and effectively.

After some actual experience in the exact procedure of this measurement musicians can readily identify such types among their musical friends. It is a part of their character and a fairly constant trait, in terms of which we recognize our friends in action.

VI. Action on Choice

Nature of complex reaction. We must, however, be careful to restrict our generalization to the thing measured — in the above case, to simple reaction. Some persons can do simple things well but cannot do things which require higher activities. The reaction experiment can be so arranged as to introduce and measure the time of any mental process such as recognition, memory, judgment, or decision. The central and simplest aspect of an act of will we may call choice. Ability to act upon choice may be measured in a simple and well-controlled case by using the same instruments as before, except that we add a contrivance by which the sound signal may be made weak or strong.

Method of measuring. In the typical situation, the subject is told, "The signal will be a weak sound or a strong sound; you are to react only if the weak sound is heard: when the signal is a strong sound, do not respond to it." Thus, psychologically, the situation is this: the subject must hear the sound and distinguish a weak sound from a strong sound, and then decide to act or not to act as the case may be. Thus, in a small fraction of a second the subject has perceived a signal, differentiated it from another possible

signal, and decided to act or not to act. In the simple reaction experiment the emphasis was upon the action. Here the emphasis is upon the thought and will which underlie the action in the form of choice. In action upon choice we find a larger range of individual differences than in simple reaction. The principle just presented may be adapted to hundreds of different conditions, depending upon what one wants to know in regard to characteristics of a person's action.

VII. Serial Action

Ability in sight playing. One of the common complaints in piano training is that the pupil does not read music well, which means that he does not quickly, easily, and accurately associate the note which he sees with the movement to be executed. In this respect there are very great native differences in capacity. To identify these and rate them, we have designed the serial action experiment.

How measured. We now carry the complication of the process one step farther and require the subject to act continuously, demanding the exercise of thought and will in association under maximum pressure. For this purpose we just require a person to act upon choice as above, when each act produces the necessary signal for the next response in a continuous chain, and we measure the time and accuracy of the action.

Visual motor action. The simplest form of serial action apparatus adapted for the visual motor action may be rigged up on a typewriter as follows:[1] write one full line of the four letters f, g, h, j, arranged in the order of chance and each letter used approximately the same number of

[1] Coover and Angell, Am. Jour. of Psychol., Vol. 18, 1907, p. 328.

times. Paste this slip of paper on the carrier, then clamp on the frame a small card with a slit large enough to show one letter so that every time a key is pressed a new letter will be exposed in this slit. We have, then, four signals any one of which may appear when a key is pressed. The subject is required to keep each of the first two fingers, of each hand, on a key, and is told to press the key which is designated by the letter in the slit. The instructions are given in the following written directions:

The charge.

Speed and accuracy. This is a test of speed and accuracy. Throw every effort into the work so as to make the best time that you possibly can with approximate freedom from error.

No interruption. Do not, under any condition, stop before the end of the line. Do not allow the occurrence of an error to confuse you or to stop you even for a fraction of a second. Every fraction of a second of delay counts, and every error counts against you.

Standard of accuracy. Work at such speed that you will not make more than *five* errors in each line. This is a standard of certainty which should determine your speed. You can fail by being over-cautious and slow, or by being reckless and fast.

Remember. The standard of accuracy; the record of speed; no interruption or delay allowed. The record will be a measure of your power of *application.* Do your very best.

The essentials. The act, which is repeated over and over again, is essentially this: a signal is given which calls for a particular movement, and this movement produces another signal, and so on for the seventy spaces in the line on the typewriter. The record is kept in terms of the total time required for each line and the number of errors made in each line. As a result of the instructions the number of errors will vary within a limited range so that the chief item in the record is the time. If he makes more than ten

errors in the seventy reactions, the trial is thrown out. It would be possible to make a graphic record of each act, but for the present purposes we simply count the total time it takes to complete five lines on the typewriter, that is, five times seventy reactions, and the record is given in terms of the average time for seventy reactions with its mean variation and the number of errors. These are converted into percentile rank so that the record of an individual reads, for example, that one ranks 95 on speed and 88 on errors; or another 16 on speed and 45 on errors, and so on.

Auditory motor action. For auditory motor action the same principle of measurement may be employed with the typewriter. For stimuli we use four telephone receivers, each placed at one of the cardinal points, 90° to the right, 45° right front, 45° left front, and 90° left with reference to the head of the observer. An electrical contrivance is attached to the back of the typewriter in such a way that for each movement of one of the four keys a tone will be heard in one of the receivers.

Fig. 2. — The Auditory Motor Apparatus.

Each receiver is associated with one key, and the procedure in measurement is then entirely analogous to that in the visual motor experiment just described. This apparatus, designed by Mr. C. F. Hansen, is shown in Fig. 2.

VIII. Precision in Movement

Steadiness and delicacy of touch. Thus far we have considered the speed and accuracy in action in different stages of complexity of mental activities. We shall now

study the character of the movement. Some persons have a delicate control of muscular movement, others are fumblers and always will be. Some, while not delicate in movement, have a steady nerve; others, although very delicate in their touch, have erratic and nervous tendencies which result in loss of precision of movement. The precision may be observed in direction, distance, speed, or force of the movement.

The precision target. To test for direction of movement in its simplest form, we use what is known as the precision target. A target is made from a Brown and Sharpe drill gauge mounted on a small board with a firm pasteboard between the drill gauge and the board. A pen holder, like a fountain pen, has a needle point which is connected through a battery, a bell, and the drill gauge in such a way that, if the needle touches the plate, the bell will sound. The test consists of determining how many holes the subject can put the needle into without touching the target plate. The metronome is beating, and he is required to put the pointer into each successive hole at the rate of one in two seconds. We start with No. 28, and the record is kept in terms of the number of the hole at which he failed as indicated by the ringing of the bell. Usually twenty-five series of trials are taken, and we find on the average how small a hole he could get down to, and what the mean variation was for that ability.

Bearing on music. The test proceeds on the assumption that an arm and hand movement is an early acquired natural movement, and that, other things being equal, the control of the hand is a pretty fair index to the ability to control any other part of the body. While this does not have an exact counterpart in music, we do measure here a condition which

plays an important rôle in the development of touch in playing.

Other tests analogous. Analogous tests may be made for each of the other aspects in precision of movement, particularly precision in the distance, the force, and the form of the movement. In each case the test is on the ability to make a simple, prescribed, and measurable movement.

IX. Discrimination

Discriminative action is action which involves the ability to make fine distinctions in movement at will. As in precision, we are interested in the kind, the direction, the distance, the rate, and the force of movement. To measure the motor discrimination for force in movement, we may use an ordinary spring balance. The subject is asked to put his finger on the plate and press down any moderate amount, say fifteen ounces, and then to make the least producible lighter pressure. This procedure is repeated a sufficient number of trials. The record is kept in terms of the average difference in pressure in reproducing the standard. The first pressure should always fall between ten and twenty ounces. Analogous measurements may be made for discriminative action in each of the other aspects of movement.

X. Strength and Endurance

The ergograph. For many purposes a test of physical strength and endurance is necessary. To measure this we use the elbow ergograph, which is a simple, strong spring. A person stands with his arms free from any support, the upper arm hanging free at the side and the lower arm bent at the elbow forty-five degrees forward, the wrist kept

straight. In this position, using only the elbow musculature, the subject is required to lift as high as he can by the handle on a graduated spring. Attached to the spring is a recording device, which makes a series of tracings, one for each pull, showing exactly how many pounds of pull was exerted in each successive trial. The subject is required to keep time with the metronome, making one pull every three seconds (each time to the utmost limit), and this is kept up for thirty trials.

Factors in the records. In such a test we get a measure of the strength of a particular set of muscles, the endurance in a maximum effort, and the regularity with which this maximum effort is kept up. In the record we have on one hand a measure of the strength and endurance, and on the other hand a record of reliability in the exercise of a maximum effort. A person with good motor control will produce a uniform series with a gradual decline, whereas a person with erratic tendencies will make sporadic efforts, the strength exerted being very variable from trial to trial.

Summary. In general, experimental psychology now enables us to measure with adequate precision any form of physical action, both as to quantity and quality. We are also able to isolate, or measure, in conjunction with other factors, speed and accuracy of various mental processes which may be the antecedents of action. The types of measurement here rated are, perhaps, among the most basic, but they should be regarded merely as types of which there may be countless variations and along side of which may be found other types of equally fundamental character. They may suffice to demonstrate that we have at our disposal means by which we can measure any form of musical action that may be desired.

CHAPTER X

MUSICAL ACTION

I. Introduction

The question may well be asked, Why not make your tests for musical capacity tests in actual music? The situation is analogous to a recent investigation of the ability of an expert marksman. After describing the tests actually used, the writer says: [1]

"Some may say, in fact, 'Why not give a man a gun and let him show his ability by shooting a few times!' Well, there are good reasons. In actual shooting, experience plays too large a rôle. The novice must be shown how to hold the gun, whether to grasp it tightly or laxly, whether his bodily muscles should be held lax or taut, how much of the front sight should be visible in the notch of the rear, whether he should aim at the bottom, center, or top of the bull's-eye, whether he should 'hold steady' on the bull's-eye or move up to it, not to mention the adjustment to and fear of the noise, flash and 'kick.' The knowledge of these conditions and the adjustment to them depend mostly on experience in shooting, not upon *innate* ability to eventually become a good marksman. The laboratory tests aim to measure this undeveloped ability, although the present series may not do so adequately."

[1] Gates, "The Abilities of an Expert Marksman," *Jour. of Applied Psychol.*, 1918, II.

Two resources. We cannot employ ordinary musical exercises, because, to be of service in selection, the test should be made before the student is trained in music. Furthermore, musical exercises are complex material, unfit for use in experimental work; and ability in musical exercises, such as actual singing and playing, changes very quickly with practice or training. We are, therefore, thrown back upon two resources: one is to found the diagnosis upon basic tests of motor control as outlined above; the other is to devise specific tests in which one element in musical action is isolated and measured under control. Fortunately, both of these methods are available and valuable, and the latter may be expanded indefinitely to supplement the general findings of the former.

An assumption. In much of the discussion of musical action, it is necessary to assume the existence of the sensory powers and the higher intellectual powers. Let this be granted once for all for the sake of brevity. We may then proceed to consider each of the capacities for musical action in turn.

II. Pitch

Factors involved. The rendition of pitch may be either vocal or instrumental, and the latter may be either mechanically controlled or controlled by the performer. With the performance in which the pitch control is mechanical, as in the piano, we are not here concerned. Singing in pitch and playing in pitch, as on the violin, require certain common elements aside from musical sensitivity and a musical intellect. They both require that sort of brain control which is measured in terms of the basic forms of action described in the foregoing chapter. The finger adjustment

in the playing of the violin requires such an extraordinarily quick and fine precision in movement that, when the movement is stated in terms of thousandths of a second of time or thousandths of an inch in movement, it seems astonishing that the human organism should be capable of such quick and delicate adjustment. Such ability is absolutely certain to manifest itself in careful measurements of motility, simple reaction time, complex reaction time, precision of movement, and discriminative action, both as to time and reliability. A high rating on these capacities, however, will not necessarily prove that the subject will make a successful player or singer. It simply certifies a capacity for action which must be evaluated in terms of the presence or absence of other capacities which are essential.

What we measure. This situation with reference to the violin player has its analogy in many other instruments, and indeed in the pitch innervation of the human voice. One reason for this lies in the fact that the delicate control required in pitch production depends upon the general quality and stability of the brain. It remains to be established by experiment whether quickness and reliability, for example, in speaking movements, may be pointed to as an index to the control of the vocal cords. In the light of present knowledge of psychology, it is fair to assume that there is a close relationship, so that when we know the speed and reliability of the motility, reaction, or precision of a finger movement, that may be pointed to as a personal equation, or trait, which will appear relatively the same in movements of another finger, a foot, an elbow, a nod of the head, or even the action of the vocal cords. This does not imply, for example, that a good violinist could do equally well in voice; for motor control is only a small factor in

"voice." Yet there is only one qualification for skill in the rendition of pitch, and that is control of movement, whether it be the movement of finger, arm, or vocal cords. Therefore, when we have a general picture or personal equation of a person's tendency in motor control, we have a fair quantitative index to the control of musical pitch.

If we turn, then, to specific tests of this ability in tone production, we can readily measure achievement, both in playing and in singing; and in doing so we ordinarily take one specific element of tone production, such as the reproduction of a keynote or the singing of an interval.

III. Seeing Yourself Sing[1]

It is possible to make vibrations which produce a tone to the ear; also produce a picture to the eye—a picture which reveals details of pitch faithfully and far more finely than the ear can hear, and which may, therefore, be employed for the objective measure of pitch and as a guide in training to sing and play in pitch. The singer standing before an instrument sees in clear pictures every pitch movement of the voice as he is singing; he sees exactly how many vibrations per second the vocal organs are producing, and thereby can tell, at the very moment of singing a note, what error is involved, even down to the hundredth of a tone; he can practice before the instrument by the hour with the opportunity of seeing the error in every tone and controlling the voice and the ear by the eye at pleasure; he can study in detail the attack, the sustaining, and the release of a single note; the player of the violin, flute, cornet, or other instru-

[1] We may profitably introduce here this description of the tonoscope and its uses, essentially as read before the National Music Teachers' Association in 1915, and printed in *Science*, N. S. XLIII, 1916, 592 ff.

ment may treat his instrument in the same way; a person at a distance may connect "long distance" with the tonoscope and project his voice or instrument on this screen hundreds of miles away; a scientist or a musician may take a phonograph record of the tonal effects under observation and ship the cylinder to the laboratory, in which it may be

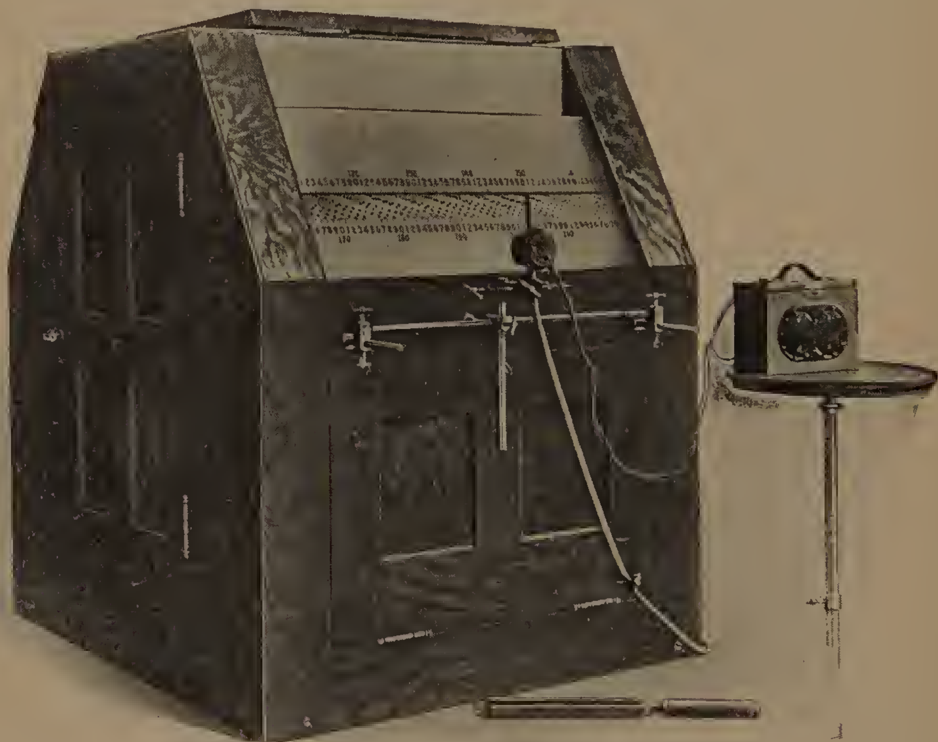


Fig. 1. — The Tonoscope.
The instrument seen at the right is the acousticon.

reproduced upon the tonoscope; the student of primitive music can transcribe the phonograph record by this method; the scientist can undertake technical studies on pitch which involve exact measurements and instantaneous recording in actual singing; the student of public speaking can study the inflections of the voice objectively and train for mastery;

the teacher of the deaf can place his pupil before the instrument and train him to speak with pleasing inflection of the voice by practicing with the aid of the eye. This array of claims may seem extravagant, but these and many other related achievements are made possible by the development of a ready and accurate method of registering pitch. The instrument which will do this is known as a *tonoscope*, and is now available for use in the studio.[1]

The principle of the instrument. The tonoscope shown in the illustration, Fig. 1, works on the principle of moving pictures, technically known as stroboscopic vision. It converts the sound vibrations into pictures on the screen. The screen, which may be seen through the opening on the front, has eighteen thousand ninety-five dots so placed that, when acted upon by a sensitive light, they arrange themselves in characteristic figure for every possible pitch within the range of the human voice. Each figure points to a number on the screen which indicates the pitch. The dots are arranged into one hundred ten rows; the first row has one hundred ten dots, the next row, one hundred eleven dots, and so on, each successive row having one more dot than the preceding one, up to the last, which has two hundred nineteen. When the tone is sounded, the row which has the dot frequency that corresponds to the vibration frequency of the tone will appear to stand still, while all other dots move and tend to blur. The row which stands still, therefore, points to a number on the scale which designates the pitch of the tone. The screen contains a sufficient number of rows of dots to cover exactly one octave. Tones above or below this octave are read on

[1] Manufactured and sold by the Musical Apparatus Company, Cleveland, Ohio.

this same screen by multiples. To see the pitch of the tone, one has, therefore, only to see the number of the line that stands still. The tone may be sung or played under natural conditions. Indeed, one may register the tone from any distant point with which there are telephonic connections. The instrument is operated electrically and will run indefinitely without any care or disturbance. This makes the tonoscope a ready and continuously available instrument in the studio or the laboratory. The speed of the revolving screen is controlled by a tuning fork with which it must keep step, being driven by a synchronous motor.

Reading immediate and accurate. In other words, we have here an instrument which will transform the vibrations of voice or instrument to visual configurations on a scale that indicates the actual pitch of any note down to an accuracy of a fraction of a vibration — often less than a hundredth of a tone. Indeed, if we are dealing with a note as constant as that of a tuning fork or a string, the pitch will be recorded accurately in tenths of a vibration, because fractions of vibrations may be read in terms of the number of dots that pass per second in the slowly moving line. There are various graphic methods of recording pitch in use, but these are entirely too laborious and cumbersome for practical use; the tonoscope furnishes us the first ready and at the same time reliable and accurate means of registering directly the pitch of a tone as sung, spoken, or played with a musical instrument in such form that it can be operated with convenience and safety outside the technical laboratory.

The phonograph tonoscope. To meet the need of a comparatively inexpensive and portable tonoscope, the instrument shown in Figure 2 has just been designed but has not

yet been put on the market. It acts on the same principle as the larger instrument, but covers only half as many notes; *i.e.*, it covers one half of each octave. As a matter of fact, it answers nearly all the purposes of the larger instrument,

Fig. 2. — The Phonograph Tonoscope.

and is sufficiently accurate for all singing. It is light and portable and may be operated on any phonograph, the phonograph being used instead of the synchronous motor to secure constant motion of the drum.

New field of investigation. The psychology of music on the sensory side has been studied with fruitful success in recent years. But the motor side of the process — the psychology of tone production and tone control — is practically unworked and remains largely in the realm of mystery chiefly for the want of a measuring instrument. The introduction of a ready means of recording, analyzing, and projecting sound vibrations before the eye therefore opens up a most wonderful field of research both in pure science and in the art of music. The scope of the work which has thus been opened up by investigations already undertaken may be illustrated by the naming of the principal problems which have been investigated up to date, to wit: the comparison of men and women as to ability in singing of true pitch, under a large number of controlled conditions; relative accuracy of pitch within the tonal range, under various conditions; principles involved in the singing of large and small natural intervals and more artificial intervals; the effect of the strength of the keynote upon the accuracy of reproduction; the effect of the volume of the voice upon the pitch; the variation of pitch with vowel quality or timbre; the correlation of ability to sing in pitch with pitch discrimination, tonal memory, tonal imagery, sense of consonance; musical education, and other factors; the establishment of norms for the measurement of ability to sing in pitch; and the study of the effect of training the ear by the aid of the eye. The scope of this chapter will permit the discussion of only one of these, and for this purpose, the last mentioned may be chosen.

Practical use in the studio. The practical use of the tonoscope in the studio lies in the training of the ear and, therefore, indirectly, the control of the voice or instrument

by the aid of the eye. On this point we have conducted a number of series of experiments to determine the effectiveness of such training, as evidenced, for example, by the kind, the rate, the degree, and the permanence of the improvement gained by practicing with the instrument. The first of these series was begun in 1903; from that time up to the present, experiments in the training of pitch control have been in progress continuously for purposes of developing methods and means and testing results. Laying aside all technical matters and detail, we may glean from these experiments the following points of interest: Practically all singers — good, bad, or indifferent; trained or untrained; child or adult; professional or non-professional — will improve in pitch control by training with the instrument. He who cannot sing a tone may "find" himself by the eye; the average singer is slovenly about pitch until shocked by what he sees in the projected voice; the person who can sing to a high degree of accuracy — say an error of plus or minus one vibration — has abundant room for improvement within a fraction of a vibration, for the more accurately one sings, the finer the instrument registers.

Nature of gain in training. The gain in training by aid of the eye may be attributed in large part to the recognition of certain subjective and objective sources of error which may be eliminated after discovery by the instrument. The ear unchecked is lax in its control of pitch. When the eye reveals an error in pitch, it aids the ear in identifying and making concrete the elements of hearing which had before remained undifferentiated and unrecognized. The seen tone serves both as a whip and as a guide in pitch near the lower limits of the ear, and is, therefore, the best incentive for improvement. Among the objective disturbances

are the effect on pitch of the loudness of the keynote heard, the loudness of the note sung, the quality of the tone heard, the quality and register of the tone sung, the vowel of the syllable sung, the duration of the tone, etc. Among the subjective factors the most complicated one is the factor of effort of attention. Ordinarily one sings more accurately when he tries; yet when one comes to a certain stage he will sing better if not conscious of a specific effort to sing in pitch. Fears, theories, anticipations, and illusions also modify the pitch. Under certain circumstances accuracy in pitch may be a mark of the general condition of the system.

Training in intervals. Training with the eye improves the ability to form concepts of intervals and sing them with increasing accuracy. Who can sing, or knows when he has sung, the chromatic scale or even a single half tone? With the instrument he can place the exact note in tempered scale or in just intonation and study in detail effect after effect; he has control for mastery since the instrument registers much finer distinctions than the ear can hear. Here again we have found that there is room for improvement for all. One man who thought he was tone-deaf was trained to sing a tone interval with a high degree of accuracy. One well-known singer was struck with despair when she saw how badly she sang the natural scale.

Training in voluntary control. Training the ear with the eye enhances ability in voluntary control of the voice as in raising and lowering of the pitch. The improvement in this is astonishingly rapid; and the reason for all this rapid improvement lies in the fact that one sees the tone the moment he sings and hears himself sing it, and can at will identify the direction and exact amount of the error.

As has been pointed out, this seeing of the tone serves as a whip and also as a guide to specific effort.

Training in attack, release, and sustaining, etc. Singing a note may be fractionated, that is, separated into its parts so that one may study, from moment to moment, the attack, the release, and the sustaining (with its various periodic or progressive changes in pitch, both desired and undesired). The instrument enables the singer to take each of these in turn and to establish mastery under the criticism and guidance of the eye.

Transfer of gain. The gain made in singing with the aid of the eye is transferred into auditory and motor control. The improvement which takes place in singing with the instrument is very rapid, and one would, therefore, suspect that it would not be permanent. But experiments show that if the training be continued for a few days with the instrument, the gain will be transferred to the ordinary singing without the instrument. This is the most encouraging feature in the process and deserves to be analyzed in great detail for the purpose of a pedagogy of singing; this we are now attempting to do in the laboratory. Such questions as these arise: How is association transferred from the visual to the auditory-motor? What are the common elements in visual and auditory control? How can we isolate each of these factors for the purpose of reduction of errors?

Adapted for set drill exercises. This type of training is convenient, inexpensive, and rigid. The pupil may be assigned any one of a hundred exercises in pitch training and practice all by himself under correction at every tone production; it may be to reduce a tendency to sharp or flat, to eradicate a tremulo, to gain control of a vibrato, or any

other pitch figure the master may set. It gives opportunity for control drill under the severest correction at every state.

While the above account transcends the bounds of our immediate subject, it gives a rather full and concrete setting to the problem in hand.

Measurement of voluntary control of pitch. The best single measurement of natural capacity in pitch control is obtained by measuring the smallest difference in pitch that the observer can produce. The test may be made by using a set of tuning forks, such as the pitch discrimination set described in Chapter II, and sounding different small intervals from .5 d. v. up to 30 d. v., to give the pitch to the ear and determine, by means of tonoscope readings, what is the smallest interval a person can sing. Another procedure for the same purpose is to determine how large the error will be in singing a small difference, such as 3 d. v. or 5 d. v., called "minimal change" or "voluntary control" of pitch. These tests have the advantage of leading to exact measurement in an actual exercise of the pitch control in a form which is not commonly involved in musical experience.

Examples of laws determined by this method. With reference to such capacities, a number of laws have been worked out. The conclusions from one investigation in the laboratory may serve as an illustration:[1]

1. The human voice is about equally accurate, in terms of vibration, at all points well within its range; therefore, the high tones are sung relatively (per cent) more exactly than those which are low.

2. A strong standard tone (especially with low forks) is reproduced as decidedly lower than a weak standard.

[1] Walter R. Miles, "Accuracy of the Voice in Simple Pitch Singing," Univ. of Iowa, Stud. in Psychol., 1914, VI.

3. The voice can most easily reproduce pitch for those standard tones which have a rich timbre, such as the organ tone.

4. Measured in terms of average error the voice is less accurate when its volume is large.

5. Vowel quality affects the accuracy of vocal reproduction of tones. The "i" (as "i" in machine) is reproduced the highest, "o" the lowest, and "a" occupies a middle position in pitch.

6. Men and women sing in their representative ranges with equal accuracy vibration for vibration of error.

7. Women show better relative voice control than men, if judged on the basis of their mean variation.

8. With women there is a general tendency to sing sharp. Men are about equally divided in this regard, sharping, however, being slightly more frequent than flatting.

9. The average error of the voice in reproducing a tone given by a fork is 1.5 d. v. for men at range 128 d. v., and 1.5 d. v. for women at 256 d. v., in a representative group of students.

10. A small perceptible pitch difference between two tones is overestimated in the singing.

11. The average minimal producible change of the voice for men at 128 d. v. is about 5.5 d. v., and for women at 256 d. v. it is 3.5. d. v.

Figure 3. No. 10 in this series is illustrated in Figure 3, which shows that there is a general tendency to sing a small interval larger than it really should be. It also shows that, in terms of vibrations, men and women make the same error; but since the women sing an octave higher than the men, the error of the women in a fraction of a tone is only half as great as that of men.

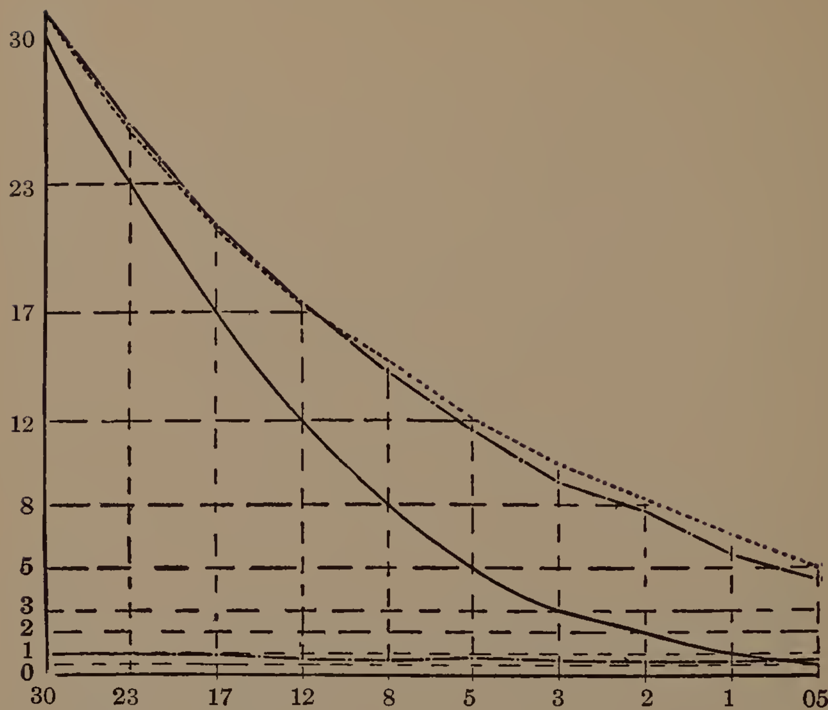


Fig. 3. — (Miles.) **Small Intervals as Sung by Men and Women Respectively.**

The scales at the left and at the bottom are in terms of vibrations, one vibration being equivalent to one fifty-fourth of a tone. The intervals as heard from tuning forks are represented in the lower heavy curve; the same intervals are represented as sung by the dotted curve for the men and by the dot-dash curve for the women. The men sang at 128 d. v. and the women at 256 d. v. The interval was always sung larger than it was heard. For example, an interval of one vibration was sung as six vibrations by women and seven vibrations by men.

Mere illustrations. These illustrations of factors that enter into pitch control are given, not as a summary of the known facts, but merely as a means of showing concretely how many factors are involved in a comparatively simple act and how these factors can be reduced to known laws and the control of conditions.

IV. Intensity

Intensity and expression. Much of the effectiveness of musical expression can be traced to a graceful and feelingful

control of appropriate shadings in the intensity of sound. Musical expression through intensity is the expression of feeling and judgment; but whether or not this feeling and judgment shall receive adequate expression in the movement depends, first, upon the natural capacity for precision in movement, as in the control of loudness, and, second, upon training. With the latter we are not now concerned.

Touch. It is a well-known fact that the natural gift for execution through intensity in music, granted the presence of musical thought and feeling, is at least as rare and as varied as a natural "ear" for music, and its existence is quite independent of the intellectual and emotional talents for expression. In so far as intensity is concerned, touch in music, when reduced to its last element, is the ability to make, instantly and accurately, fine gradations of pressure, whether it be on a key or a bow or in the energizing of the vocal cords.

Capacity may be measured. It is safe to say that the person who is eminently successful in musical execution of intensity will show his delicate control of movement in a simple test, for example, on a balance. Conversely, a child who shows natural control in a simple untrained movement is the one who may become successful in musical execution, provided he has the other qualities. The basic tests of precision in movement, such as delicacy in control of degree of pressure, rate of pressure, distance of movement and steadiness, are, therefore, of great value in measuring this capacity.

No objective standard of intensity in music. Measurements of intensity or loudness of sound in actual playing or singing have not been developed, largely for the reason that we have no absolute standard which must be attained.

Pitch presents a rigid and fixed requirement; the vibration has to be precise or it is out of tune. Loudness, or intensity, is not so fixed, but is determined from time to time by taste, facilities, and conventions.

Measure of performance. The psychology of music will, however, introduce measurements which will result in the analysis and objectifying of the significance of loudness and the measurement of actual success or failure in playing, in so far as aspects of this factor are concerned. A mechanical device may be put under the keyboard of a piano in such a way that it will make a graphic record of the form and force of the touch on the key, and reveal the objective record to the player at the same time that he hears the tone and feels the stroke. As in the case of the tonoscope, such a contrivance may then serve as a guide in training or for the purpose of analysis of recognized finish in technique which one may desire to imitate. Such procedure will train both ear and hand because the graphic record is quantitatively exact and records smaller differences than the untrained ear can hear or hand execute.

V. Time

Of the capacity for keeping time in musical action, we have a specific measure in the above test of timed action, Chapter IX. This is effectively supplemented by the records on motility and reaction time. The timed action test may be regarded as an imitation of keeping time, as in the playing on the piano, marching, dancing, and all other forms of rhythmic movement. The merit of the test lies in the fact that it is stripped down to its elements, which can be accurately defined, controlled, and measured. The test is, of course, capable of hundreds of variations, depending upon

a specific interest that one may have in mind. It is the third of the three fundamental capacities — the control of pitch, the control of intensity, and the control of time. Its principal significance lies in the rôle that it plays in rhythmic action.

VI. Rhythm

Rhythmic action very complex. The psychology of music is the psychology of tone and rhythm. The question just now before us is the rôle of motor capacity in rhythmic action. The reader must be patient with our failure to give, in a single section, a full account of musical rhythm. Rhythm, like tone, is present in all aspects of music. We are compelled to consider one factor at a time, the hearing of time, the hearing of intensity, the imaging of time, the imaging of intensity, motor impulse, action in time, control of intensity, precision in movement, and other factors.

Measurement of time factor. On the motor side, the process must be divided into the control of time and the control of intensity. Of these we have specific measurements in tests on timed action and precision and discrimination in action. Mere uniform action, as in timed action, is not objectively rhythmic. To be rhythmic there must be objective grouping, either by time or by intensity. Precision in the time of rhythmic action may be measured by varying the timed action tests so as to produce long and short intervals, the duration of which may be controlled as in actual playing. The recording apparatus might be attached to the piano, but this would be clumsy and inexact. We, therefore, use the telegraph key with the chronograph, as before, and require the subject to mark a given musical rhythm, such as repeated measures of a long and a short

note. Such a test is, however, not so valuable as a test of timed action for the reason that so much depends upon practice. However, it deals with a specific and additional factor, the ability to produce multiples of a given time, as when we regard the half note as equivalent to two quarter notes.

Measurement of intensity factor. To this measure of time precision, we might easily add the measure of the precision of stress or accent, as described for intensity. To record this, the telegraph key is mounted on a spring which is attached to a similar spring on the phonograph, carrying a tracing point which marks the degree of pressure by a tracing parallel to the time line and similar to it, except that the measure is in terms of the degrees of pressure; that is, amplitude of the jog instead of the time. Such apparatus might be available and effective for specific training in precision of time and touch in the essentials of musical rhythm and might well furnish a series of exercises in a conservatory.

The motor impulse. Should we desire specific tests of motor tendencies in rhythm as marks of rhythmic impulse, such can be devised in considerable number and of various kinds depending upon what is wanted. But for the purpose of guidance, such motor tendencies can be observed with sufficient accuracy without any instruments by one who has been trained in the analysis of such responses and understands what to look for.

Analysis necessary. When we come to analyze difficulties and defects, it is necessary to separate the capacity into its component parts and isolate each factor on the sensory, representative, affective, and motor sides as has been indicated above.

VII. Timbre

The rating of "voice." After all, the central factor in musical power of expression, whether vocal or instrumental, is timbre. Herein lies literally the beauty of richness in tone production. For voice, quantitative measurement of this capacity is, however, of comparatively little significance, because the voice changes so much in the period of natural growth and is capable of so large a transformation through training that the estimate of this capacity can be made with adequate accuracy without any exact measurement, provided the examiner understands thoroughly what factors are involved in the determination and the limitation of tone production. Rating of an untrained voice is an exceedingly complicated affair. The difficulty lies in finding masters who understand this technique of analysis which involves technical training somewhat allied to a physician's training for diagnosis.

The phonodeik. At the present time no convenient instrument is available for measuring the timbre of a tone, but measurement can be made, and is being made, through the remarkable achievements of recent experimental acoustics. With his phonodeik, Professor Dayton C. Miller [1] is able to photograph a tone from a singer or an instrument, as was illustrated in Chapter VI, and can analyze the waves in the photograph in such a way as to obtain a detailed inventory of the tone in terms of its component overtones. The instrument shows not only how many overtones are present but also the relative prominence of each overtone. Thus, in terms of the number, distribution, and relative prominence of overtones, we have an exact and concrete picture and a

[1] *Op. cit.*

quantitative statement of the character of a rich tone. This character is its timbre.

Its practical use. It is to be hoped that this process may be so simplified that the recording instrument may be put into a conservatory, not only for the testing of the voice for the purpose of rating, but also for the study of progressive acquisition of certain characteristics of timbre under controlled training. When this is done, we may select a superior tone of a master and place the photographic analysis of this as a model before the pupil in such a way that he can compare his own production from moment to moment with that of the master or model tone, and can know in exact detail just what the defects or the merits are in a given tone. It is not unreasonable to suppose that such critical examination of the voice of the artist may lead to identification of faults, not now specifically recognized, and to the correction of these through persistent and intensive training with this objective in view. Just as the tonoscope throws a moving picture of the pitch of the voice before the singer, the phonodeik will throw a picture of the timbre on the screen, and the voice may be trained in turn for pitch and tone quality through the guidance of the eye which is capable of seeing in concrete detail effects vastly finer than the ear could ever hear.

Needed, an analyzed basis for rating voices. For surveys of schools and for preliminary examination of children entering music schools, we need a manual of instructions, setting forth in detail the capacities of the voice somewhat in the way that we have here treated the capacities of the ear. The main thing is to know what to look for in the light of knowledge about possibilities of development with training. But this most important aspect of all singing remains

a field quite unexplored in so far as the scientific bearings in application to music are concerned. It will perhaps be generally admitted that voice judging and voice development and training are notoriously devoid of scientific foundation.

VIII. Consonance

The capacity for producing consonance, or harmony, in so far as it depends upon the performer, must be estimated in terms of a number of the capacities which we have outlined. There is the requirement of the sense of pitch and the ability to render pitch, the sense of intensity and a delicate touch, the sense of consonance and a command of adequate tonal range, the ability to image, both through imagination and memory, the concrete setting to be reproduced, the motor capacity for producing favorable tone quality, and the musical thought necessary for attaining a musical whole. So far as rating of musical talent is concerned, there is no need of a specific test of this complex process. We must judge capacity for this in terms of the factors involved, each of which may be rated in turn.

IX. Volume

In accordance with our analysis of volume in Chapter VIII, it follows that, as we have intensity-volume, extensity-volume, timbre-volume, and reduplication-volume, tests of promise in volume of voice lie in the tests of these specific resources; namely, force for strong sound (intensity), register for high and low tones (pitch and extensity), capacity for rich tones (timbre), and tone reinforcement (reduplicating resonance). Resource for volume, therefore, does not call for other capacities beyond those already discussed.

X. What Constitutes Voice?

The scientific analysis of natural capacities in voice as a foundation for guidance in the selection of voices, remains to be worked out. It will probably involve first, accurate knowledge of the anatomy and theory of the functioning of the vocal organs. With this must go acquaintance with particular types of structural voice defects and pathological conditions, particularly with respect to the possibility of correction or cure. The classification of facts will be expressed in terms of the physical sound wave, its frequency, amplitude, duration, and form. With such a clear concept of the sound wave, we may then examine each anatomical part — the bellows, the vibrators, the resonators — and determine exactly how each of these functions in the control of these physical characteristics of the sound wave. That description, in physical terms, can readily be converted into psychological terms, such as, pitch, intensity, time, and timbre. Having adopted the exact terminology in which the relation of the psychological to the physical is represented correctly, we must draw from the art of music the best opinion as to what kinds of sounds are desired, such as, rich, pure, voluminous, etc. From this point we may approach the question of the psychology of motor innervation, the question of how to produce these desired effects, and on the basis of such knowledge we may found methods of voice training. In order to rate young voices we must, furthermore, have well established norms of natural capacity, so that when we have, for example, measurements of chest capacity, photographic records of the vocal cords, and X-ray pictures of the resonance cavities of the head, we may know how each of these compares with established norms. In

addition to these norms of natural capacity, we must have norms of development in order that we may predict the prospect of development of a given capacity in a particular structure. Such, in brief, is the outline of the future psychology of talent for a singing voice. For instrumental talent the procedure may be analogous.

XI. General Considerations

Capacity for musical action predictable. Music is action. This action is guided by the various capacities for hearing and by the powers of imagination and memory in such a way as to be the medium of expression for artistic feeling and thought. In this chapter we have tried to analyze action to its structural elements and have found that musical performance requires certain powers of motor control which can be identified long before they are brought out by musical education. By measuring certain forms of action, we can predict with a good degree of certainty what the prospect of the acquisition of power will be for various factors in musical action. We have also found that it is possible to apply exact measurements to actual musical performance in various aspects of music. But the main lessons that should come to the general reader are the insight into the actual structure and nature of the power of musical execution, and a recognition of the possibility of noting a child's personal equation for various kinds of musical action early enough to make it the basis of intelligent choice and guidance.

Physique. In considering musical intelligence, we must consider its relation to general intelligence. So, in considering capacity for musical action, we must take into account the general equipment of physique, not only as to form of

fingers, lung capacity, and resonance capacity; but also general health, vigor, and physical resources, because singing and playing make very severe demands upon physique, and achievements are very often limited by lack of general vitality.

CHAPTER XI

MUSICAL IMAGERY AND IMAGINATION

I. Introduction

Music in representation. We have surveyed the purely sensory and motor capacities in the hearing and performing of music and are now ready to consider the content of music as re-presentation in the tonal world in which we live through mental pictures or images.

A subjective affair. If music were merely hearing and playing, we should fail to carry its æsthetic value with us in life. It would be a momentary affair, left behind us; but musical minds live in a world of tones in which there is creation, rehearsing, storing, and enjoyment of real music quite apart from the presence of outward sound.

Auditory imagery. When we have heard a tune, some of us have the power to hear it over again; it comes back to us; it follows us; it may even be so persistent as to haunt us. It is heard in imagination — more than imagination, in fact, for it is actual hearing in the absence of the outward sound. We can play the tune, hear the counterpoint, follow the resolution of the chord, admire the attack, respond emotionally to the exquisite nuances which are rolled off in our mind's ear. This is called auditory imagery. In this auditory imagery lies one of the most precious of the gifts of music, — the ability to live in a world of mental tones. In this capacity nature has bestowed her gifts

unevenly. One reason the radical difference among individuals is not well known is that those who are not blessed with this gift do not know what they lack or miss. It is like color-blindness; the color-blind individual does not perceive what he fails to see.

Examples of difference in imagery. A supervisor of one of the largest public schools in this country stated frankly that he had no auditory imagery and doubted if he missed anything. One who has good auditory imagery replied in astonishment that he could not understand what one really gets out of music without auditory imagery. Let us call them A and B respectively. A, the person who has no auditory imagery, recalls a tune or any other musical effect in abstract terms, that is, in name, in visual picture of the score, in terms of logical phrases, or in technique of the composition. This may be exact, relatively easy, and serviceable so far as it goes. But B plays or sings or has it played or sung over "in his mind"; he actually hears it, repeats parts, applies the technique, observes principles in operation, just as if he were actually in the presence of the performer. A claims that he has no auditory imagery; B, that his auditory imagery is as vivid as the original perception. Between these two extremes we have an unbroken gradation, and it is possible by a psychological scale to locate each person somewhere between A and B.

Often explains attitude of musicians. In this fact of inner experience, subjective music, or realism, the constant reverberation to musical ideas because they are lived in the concrete, lies the explanation of one of the mysterious holds of music upon some minds, and the scientific explanation of much in the art of appreciation. One person is cool and logical in his musical reaction — makes a good business

man, supervisor, or director; the other is warm in emotional response and is the artist. Here is the corner stone of "the artistic temperament."

II. Imaginal Types

Present view. Since the first discovery of imagery (only about two generations ago) there has been much discussion and experiment for the purpose of determining to what extent individuals differ in imaginal types. Without going into details as to the methods of experimentation and the large number of the factors which must be taken into account, we may state the general conclusions which have been reached in three propositions: First, there are no pure image types; that is, there are no persons who are purely visual or purely auditory, motor, or tactile. Second, notwithstanding even the contradiction of the most learned scholars and observers, it seems probable that all persons have some degree of capacity for imagery in all of the senses. Third, there is a general tendency to couch one's experiences primarily in one sense imagery. For obvious reasons the most common type is the visual, which may be more or less supported by imagery from the other senses.

Imagery analogous to perception. This tendency to live in one sense in representation is entirely analogous to the same tendency in perception, because imagery is merely a reinstatement, either free or faithful, of what has before been experienced. As I go about my office and read and write and meet people, I have a prevailing tendency to recognize things as I see them — the desk, the paper, the pen, the hat, the door knob, the caller. Most of these things could be recognized through other senses such as hearing or touch, but the eye serves the purpose, and therefore,

the other senses fall into the background, and I may not be conscious at all of how the door knob feels or how the hat feels, or how the desk feels.

Limited to sensory capacities. It is of course unnecessary to say that imagery is limited to the original sensory capacities. One does not, as a rule, imagine what he has not sensed or cannot sense. Thus limitations in hearing of pitch, time, or consonance will appear in imagery only to the extent that they are present in sensation. That is not quite so true of action. Indeed, the image of strain in motor imagery of the sort to produce a tone above one's vocal range may be more conspicuous than the image of a tone within the range; but such images are more or less in the nature of actual sensations of strain.

Spreads into all senses. Music, like all other art stimuli, arouses imagery in each and all of the senses, and the non-musical senses are by no means negligible for the appreciation of the musical effect. Many persons who are primarily eye-minded see the whole setting of the performance and get the emotional reaction largely through visual imagery. Images of warmth, taste, and smell also play an important rôle. Just as we not only see, but also hear, touch, and move toward the person with whom we shake hands, so, when we re-live this act in memory or imagination, it tends to come with the same richness of setting — the visual, tactile, motor, thermal, etc. Only thus can we feel ourselves into the situation.

Advantages of imagery. Music is, however, not a thing to be seen, touched, or smelled; nor is it essentially ideas or abstract thought; primarily, it is a creation within a world of hearing. Therefore the person who can image music vividly, profusely, and firmly as he has heard it has

a great advantage over the man who primarily sees the score and the performer, or recalls the abstract name for a formula, movement, expression, or other aspect of music. The one lives for the moment in a tonal world and hears music; the other does not enter this tonal world but satisfies himself with ideas about music or names for it.

III. General Tests of Mental Imagery

The introspective method. Of the objective tests of mental imagery none lends itself well for general diagnosis. The introspective method here recommended lacks the objective control which we have enjoyed in the foregoing tests; but it is amply justified by the fact that it draws out the practical information we want quickly and in rich setting.

The measurement of relative imagery in the different senses. The test is taken from the author's manual "Elementary Experiments in Psychology."[1] For full directions and interpretation of this test it is necessary to consult the original text.

Directions. Fix clearly in mind and use as consistently as possible the following scale of degrees of vividness:

0. No image at all
1. Very faint
2. Faint
3. Fairly vivid
4. Vivid
5. Very vivid
6. As vivid as perception

Answer the following questions by writing after the number of the question the number which denotes the degree of

[1] Holt & Co., 1908.

vividness characteristic of your image. Instead of taking the questions in the order given, follow the order: I 1, II 1, III 1, IV 1, V 1, VI 1, VII 1, VIII 1, I 2, II 2, III 2, IV 2, etc., I 3, II 3, III 3, IV 3, etc. Introspective notes to supplement the numerical answers are very desirable.

I. VISUAL. 1. Can you image the color of — (*a*) A red rose? (*b*) A green leaf? (*c*) A yellow ribbon? (*d*) A blue sky?

2. Can you image the brightness of — (*a*) A white teacup? (*b*) A black crow? (*c*) A gray stone? (*d*) The blade of a knife?

3. Can you image the form of — (*a*) The rose? (*b*) The leaf? (*c*) The teacup? (*d*) The knife?

4. Can you form a visual image of — (*a*) A moving express train? (*b*) Your sharpening of your pencil? (*c*) An up-and-down movement of your tongue?

5. Can you image simultaneously — (*a*) A group of colors in a bunch of sweet peas? (*b*) Colors, forms, brightnesses, and movements in a landscape view?

6. Can you compare in a visual image — (*a*) The color of cream and the color of milk? (*b*) The tint of one of your finger-nails with that of the palm of your hand?

7. Can you hold fairly constant for ten seconds — (*a*) The color of the rose? (*b*) The form of the rose?

II. AUDITORY. 1. Can you image the sound of — (*a*) The report of a gun? (*b*) The clinking of glasses? (*c*) The ringing of church bells? (*d*) The hum of bees?

2. Can you image the characteristic tone-quality of — (*a*) A violin? (*b*) A cello? (*c*) A flute? (*d*) A cornet?

3. Can you repeat in auditory imagery the air of — (*a*) Yankee Doodle? (*b*) America?

4. Can you form auditory images of the intensity of a violin tone — (*a*) Very strong? (*b*) Strong? (*c*) Weak? (*d*) Very weak?

5. Can you form auditory imagery of the rhythm of — (*a*) The snare drum? (*b*) The bass drum? (*c*) "Dixie," or other air heard played? (*d*) "Tell me not in mournful numbers" spoken by yourself?

III. MOTOR. 1. Can you image, in motor terms, yourself — (*a*) Rocking in a chair? (*b*) Walking down a stairway? (*c*) Biting a lump of sugar? (*d*) Clenching your fist?

2. Does motor imagery arise in your mind when you recall — (*a*) A waterfall? (*b*) A facial expression of fear? (*c*) The bleating of sheep? (*d*) Two boys on a teeter board?

3. Aside from the actual inceptive movements, do you get motor imagery when recalling — (*a*) A very high tone? (*b*) A very low tone? (*c*) Words like "Paderewski," "bubble," "tête-à-tête," "Hurrah!"?

4. Can you form motor images of — (*a*) An inch? (*b*) A yard? (*c*) A mile?

5. Can you form a motor image of — (*a*) The weight of a pound of butter? (*b*) Your speed in running a race? (*c*) The speed of an arrow?

IV. TACTUAL. 1. Can you form a tactual image of the pressure of — (*a*) Velvet? (*b*) Smooth glass? (*c*) Sandpaper? (*d*) Mud?

2. Can you form tactual imagery of the following impressions made in the palm of your hand — (*a*) The size of a certain coin? (*b*) The direction of a line traced by a pencil point? (*c*) The intermittent touch of a vibrating body?

3. Can you form tactual imagery of — (*a*) The flow of water against the finger? (*b*) The sensation from a pressure spot? (*c*) The weight of a particular coin in the hand?

V. OLFACTORY. 1. Can you image the odor of — (*a*) Coffee? (*b*) Camphor? (*c*) An onion? (*d*) Apple blossoms?

2. Can you image odors from — (*a*) A meadow? (*b*) A confectioner's shop?

VI. GUSTATORY. 1. Can you image the taste of — (*a*) Sugar? (*b*) Salt? (*c*) Vinegar? (*d*) Quinine?

2. Can you image the taste of — (*a*) An apple? (*b*) A chocolate cake? (*c*) Beefsteak?

VII. THERMAL. 1. Can you image the coldness of — (*a*) Ice cream? (*b*) A draught of cold air? (*c*) The sensation from the stimulation of a cold spot?

2. Can you image the warmth of — (*a*) Hot tea? (*b*) A warm poker? (*c*) A warm bath? (*d*) The sensation from the stimulation of a warm spot?

VIII. Pain. 1. Can you secure a sensory image of the pain of — (*a*) The prick of a pin? (*b*) Running your finger along the edge of a sharp knife? (*c*) A toothache or headache? (*d*) The stimulation of a pain spot?

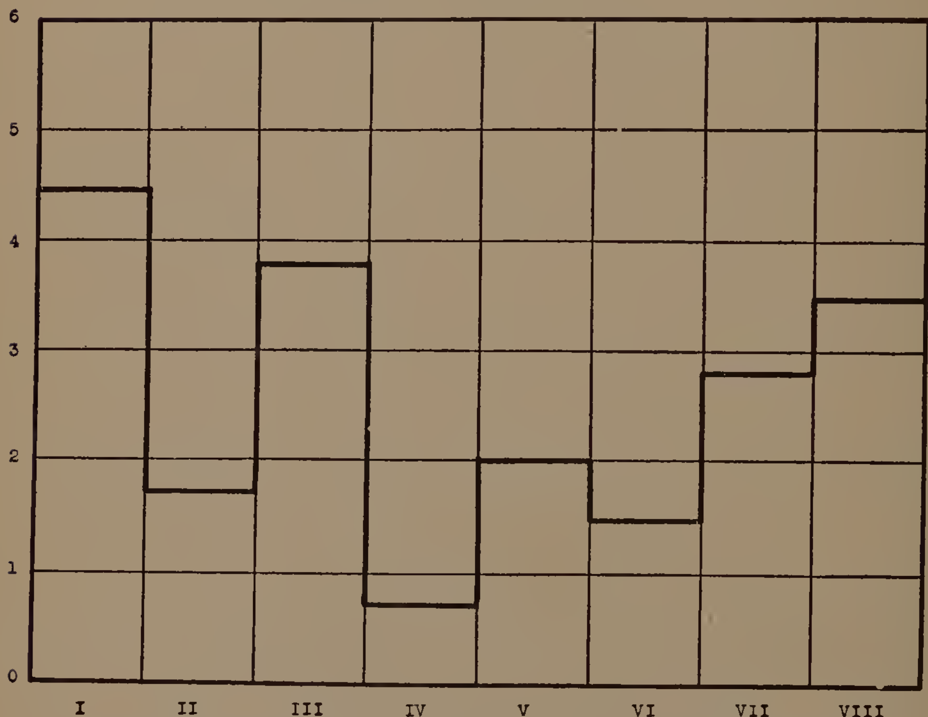


Fig. 1. — Relative Prominence of Imagery in the Different Senses.
Sample of an individual chart.

Compute the averages for all the answers in each of the experiments I to VIII. Lay off a plot in pencil as in Figure 1, eight blocks long and six high, and number as in this figure, where the vertical series represents the scale of vividness from 0 to 6, and the horizontal series represents the senses I to VIII. Plot the averages in a curve as in Figure 1.

IV. A Simple Test of Auditory Imagery in Children

Preliminaries. The simplest and most effective procedure for the testing of auditory imagery both in children and adults is to begin with some illustrations of imagery in vision; for example, recall of the breakfast table. Ask them to notice to what extent the whole table is present, to count the dishes, to notice the design on the tablecloth, etc., in order to develop an attitude of accurate observation. Then ask them to see a small yellow rose, fifteen inches in front of the eyes; ask them to put three rose leaves back of this yellow rose; then let them put with the yellow rose and its leaves a little red rose and then a pink one. For each of these objects there should be drill in the rating in terms of the scale from 0 to 6 as outlined above. In observing visual imagery the eyes should be closed.

Preliminary warning should then be made that imagery is no mark of intelligence because sometimes very intelligent people have very little imagery and sometimes they have very marked imagery, and the same is true of very ignorant people and of people of low intelligence. Then their attention should be called to the fact that images do not always come with the same clearness, firmness, or permanence, and that their record must be a sort of average representing the commonest experience. Having practiced in this way on the rating of visual images, one may ask how many have ever been haunted by a tune, or how many actually hear a tune in imagery. Then some illustrations may be given, such as grading themselves on hearing the patter of rain, the voice of the teacher in speaking the pupil's name, the bark of a dog, or the honk of an automobile. All this is preliminary.

Then the following specific tests may be made:

I. **The broken melody.** Play the first two phrases of "America" so that all may know what it is; then announce that you will play a few notes but may stop any place and that the listener is to image the next note. After the note has been imaged the actual note is played and the listener is

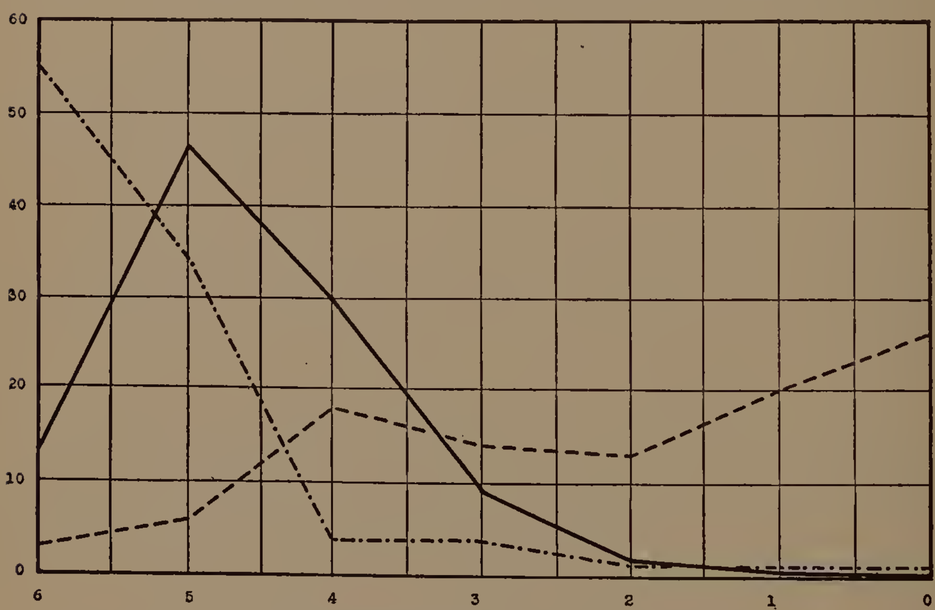


Fig. 2.— Distribution of Ratings in Auditory Imagery.

Solid line, unselected adults and children; dot-dash line, musicians; dash line, psychologists. Figures at the left, per cent of cases; at the bottom, vividness of the image.

to grade himself by the scale of 0 to 6 on the imaged note as compared with the actual note. This is repeated ten times, the imaged note being always a sustained tone.

II. **Imitating two notes.** The experimenter plays two notes three times and asks the listener to play them as images in the same way. This is repeated ten times with different notes.

III. **Free imaging.** The listener is asked to image the first phrase of "America" as played in the first experience. This is repeated ten times.

Records and norms. The final record is given in terms of the average rating for these thirty trials. A norm of distribution is shown in Figure 2 for adults and children. Curves representing psychologists and musicians respectively in this figure must be discussed separately. This norm may be converted into percentile rank as in the sensory tests.

V. The Development of Auditory Imagery

Nature of development. The child is naturally of the imaginal type, and probably has as vivid images as the adult will ever have. The process of specialization in culture, learning, and skill is really a process of suppression of the prolific images characteristic of childhood. What happens developmentally then is that, given a certain type, for example, auditory-motor, there will develop with this capacity a richness of recognition and a power of differentiation which is entirely analogous to the development of command of timbre and other pitch complexes with a given sense of pitch. It does not mean that development necessarily results in stronger imagery but rather that the things imaged are more familiar, of richer variety, and of far keener differentiations than in earlier childhood. It is probably this latter aspect that musicians have in mind when they speak of developing imagery, just as they have in mind the richness of experience when they speak of the development of the sense of pitch.

Children and adults. The distribution of ratings of children in the four years of the grammar school practically takes the same form as for adults. We have, therefore, represented them in a single curve in Figure 2 and in a single norm in Figure 3. This means that, in responding to the same test of vividness of auditory images, children rate themselves

about the same as adults when an unselected group is considered. Children respond very well to these tests. There need be no hesitation about using these tests in the series of measures of musical talent in the school. This self-rating must, however, be interpreted with care in the light of the

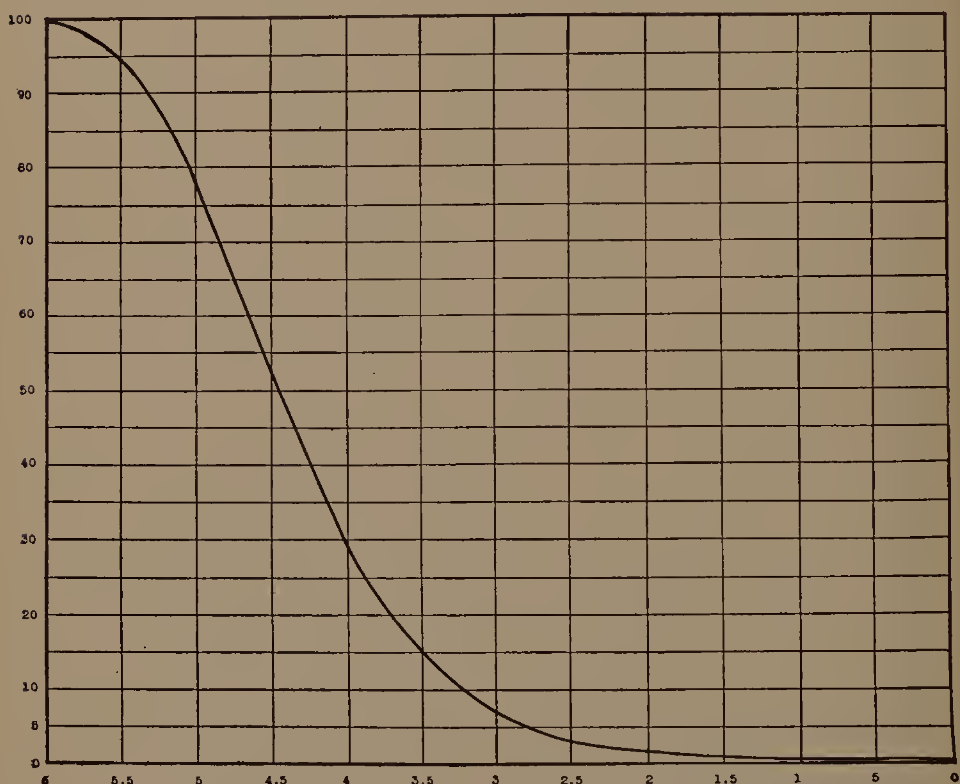


Fig. 3. — Norm for Converting the Rating into Percentile Rank.

objective records in the other measures, and the skill of control in the giving of this test.

Preventing atrophy. On the whole, the results of observation on children and adults tend to show that, with training and mental development, we do not develop any new capacity for vividness of imagery but the ability to put the native capacity to a far greater and more diversified

use; and to the extent that this is done, we have forestalled the otherwise inevitable suppression and atrophy of this capacity, which is a common occurrence.

"Sudden" appearance. Many music teachers speak of having found themselves, and of having had pupils find themselves, suddenly developing the use of auditory imagery as if it were a new power which had just been acquired. The explanation of this is probably to be found in the interpretation that a new interest has developed. The situation is the same as with the art student who may have had a keen eye for color vision up to the time that he takes training in painting, when it seems all at once as if a new world of color were being revealed to him. He sees colors and interprets them where they have not been seen before, and yet there is no reason for saying that this has changed his natural capacity for seeing colors. It means simply that he was not interested in his power or did not have his attention directed to it before.

VI. The Rôle of Auditory Imagery in Music

A basic trait of musicianship. The best-informed musicians agree that the power of imagery is one of the essential gifts of a musician. A study of the biography of the great composers reveals the fact that they have all had power of imagery to a high degree, although there are very great differences in the kind of musical imagery and its relation to feeling and thought. Musical biography, in so far as it is psychological, is more conspicuous in its terms of imagery and responsiveness to this musical world of images than in anything else.

Rôle in composition. The best composers urge their pupils to compose without the use of an instrument. This

is of course possible in terms of abstract technique of composition; but, in order to get the real inspiration, the composer is advised to relax himself and hear spontaneously the thing which is produced before him under the influence of the constructive imagination and thought in which he has approached the subject. Having written this down as it was heard, he is then urged not to try it on an instrument but to play it mentally again, because in playing on the instrument the consciousness of technique and rules will be thrust upon him in such a way as to make the composition conventional; whereas, when playing the thing mentally, this spontaneity much more naturally brings out any change which would be desirable from the point of view of the expression of his own feeling. It is the old story. One must acquire technique through patient plodding and effort; but when this is once deeply ingrained in the system it crops out automatically in spontaneous self-expression.

This testimony of the composers of the past is sustained by the leading composers of to-day. The natural method of composition is to hear the theme which is being developed in imagination as if it were actually performed, and to hear it so realistically as to experience the feelings which naturally ensue and to be able to observe and to criticize the finest points and shadings in timbre, harmony, rhythm, or other aspects in this subjective rendition.

Rôle in performance. What is true of composition is also true of performance. A musical selection can be played mechanically by a human being as well as by a machine. It can be played with feeling by a person who can lose himself in the present moment by projecting himself into the score in such a way that each successive sound moves in a

rich setting of mental imagery so realistic that it blends without break into the actual sounds. This imagery moves like an accompaniment; it forms the matrix in which the playing is set; it gives the performer his bearings.

Rôle in hearing. If this is true of composition and performance, it must, of course, be true also for the ordinary hearing of music. An inquiry among musicians reveals the fact that teachers regard such ability to image music, to re-live it, to recall and rearrange in realistic imagination, as an essential mark of musical capacity and of progress in the appreciation of music.

VII. Actual Prevalence of Musical Imagery in Musicians

A questionnaire. For the use of a student[1] working on this subject, the writer issued a circular letter to two hundred musicians and two hundred psychologists, asking the first test of psychologists, and both tests of musicians.

"We are seeking information about (1) what degree of tonal imagery prevails among musicians; and (2) the judgment of musicians as to the rôle of tonal imagery in music.

"By auditory imagery (usually called mental hearing), we mean the ability to hear sounds in imagination and memory, to some extent as if they were physically present to the ear.

"For the purpose of rating imagery, we use the following scale:

0 — no image	3 — fairly clear image
1 — very faint image	4 — clear image
2 — faint image	5 — very clear image
	6 — as clear as the actual hearing

"If you will have the kindness to try the two tests and answer the following questions, we shall be under great obligations to you. The names of all contributors will be kept confidential.

[1] Dr. Marie Agnew.

"TEST 1. Shut your eyes and try to *hear* in your imagination the first phrase of 'America' as played on the piano. After repeated trials, record your average grade, marking on the above scale.

Grade........................

"TEST 2. Compose a phrase of an original melody, to be sung by a specific person, and hear it over and over again in your imagination. Record the grade of the image on the above scale.

Grade........................

" *Questions*

1. Do you naturally recall music vividly in realistic auditory imagery?
2. Do your compositions always come naturally to you in realistic auditory imagery?
3. Has your own auditory imagery developed or tended to regress as you have matured?
4. Do you find great differences among your pupils in auditory imagery?
5. What significance do you attach to such differences, if any?"

Some facts gleaned. Without entering into a discussion of the returns to the questionnaire in detail, it is possible to glean some rather striking facts. Tabulating the answers of Question 1 for musicians and psychologists, we have the two curves in Figure 2 showing that musicians rate themselves as having extraordinarily high auditory imagery whereas psychologists rate themselves low. We take the psychologists as representatives of men of science, trained in accuracy of observation of this kind, and the musicians as representatives of those who have natural gifts in music. In so doing we must, however, remember that there are some among the musicians who do not have musical talent, and there are among the psychologists some who are musical. As a rule the musicians who rate themselves low offer some excuse, explaining that they suffer from defective capacity in this particular; that they have neglected to develop it; that they have been engaged in some sort of musical busi-

ness which does not make it necessary, etc. Likewise, the psychologists seem to infer that the lack of this power is an index to their lack of musical ability.

In both classes there are a few exceptions to this rule; for instance, a few musicians and psychologists recognize the fact that one may have marked auditory imagery without a musical mind, and a few seem not to be able to grasp either the fact of the existence or the significance of imagery of any sort.

The outstanding fact, after due allowance for the crudeness of the test and the many sources of error which enter into the report, is that the great musicians have an auditory imagery which is almost unheard of among unmusical men of science.

Typical comment. Among the interesting comments which accompanied the replies the following are typical. The imagery is not readily under voluntary control. It comes, or it does not come, spontaneously. It varies from time to time depending upon favorable or unfavorable associations. It comes very much more readily for a familiar situation than for one that is not familiar; for instance, it is easier to hear "America" sung than to hear it played on the piano; it is easier to hear one person than another; certain parts may stand out with clearness while other parts fail; one may hear the tones for a moment and then they are lost. The tones are so tied up in rich auditory and kinesthetic imagery that it may be difficult to isolate one from the other for observation. Many cannot hear themselves sing or play unless they are actually conscious of having gone through the movements in an inceptive form.

Musicians claim good auditory imagery, and that it has developed. Musicians certify that, as a rule, they naturally

recall music readily in auditory imagery and that the compositions naturally come to them in this form through creative imagination. Most of them maintain also that their imagery has developed with training. No musician reports that it has declined.

The musicians' theory of development. Responses to Questions 4 and 5 reveal the character of the psychological theory and insight that music teachers have with reference to their pupils. Here we find the greatest diversity of opinion, from the view of those who believe that all children are alike in this capacity to that of those who believe that children as a rule are very different and that no amount of training can make them alike. On the whole, musicians put large faith in the power of developing imagery through training and emphasize the necessity of beginning early.

VIII. Motor Imagery

Intimately related to auditory imagery. Auditory imagery is almost inextricably tied up with motor sensations and motor imagery. A musician with auditory imagery and imagination is cool and stale if he does not have these bound up with motor imagery and motor tendencies. Motor or kinesthetic imagery is the mental picture of movements and tendencies to movements in terms of feelings of effort and sensations of movement. In music, motor imagery is the reliving of sensations of strain in movement which were experienced in the actual sensations of hearing or would naturally accompany an imagined hearing. It is in large part the raw material of emotional expression in music and is usually confused with emotion from which it should be clearly distinguished as merely one component element.

Its significance. One person who has defective motor

imagery is, perhaps, unmoved by music to that extent. He may have the most refined æsthetic appreciation of music as something heard, but he has no feeling of how every musical effect is accompanied with sympathetic feeling in the execution. He does not feel the stress and strains in his body which are the emotional reaction in the original hearing, or would be in a real or imaged hearing. He misses the subjective living over, not only of the effect on self or another in producing the tonal effects heard, but also the awareness of the entire organism as felt in a thrill through the countless reactions in muscles and internal organs, which constitutes the outward expression of the emotion aroused by the sound. Another person, who has good motor imagery, lives in a world of emotional responses. If he listens to the subject of music, he feels himself producing it sympathetically. He finds himself responding emotionally, often in a false and figurative way as in feelings of enlargement, expansion, and strength. Where the musician "projects" himself into music, or "lives it," he couches himself essentially in motor imagery. These are not characteristically separate images, but rather a full setting, even an ideal.

How it radiates. The commonest experience in observing auditory imagery is to find it set in a mass of visual and motor sensations and images. One sees and feels himself actually producing the tone vocally or instrumentally, and then, under favorable conditions, he hears it. This is made doubly complicated by the fact that the actual movement of tone production is present to some extent as an inceptive movement in nearly all thinking of tones. The movement may be infinitesimally faint, but the more carefully we make our observations the more certain we are to find these sensations.

Relation to motor sensation. Indeed, the kinesthetic sensations are so conspicuous that many persons doubt whether they have any images of motion in addition to the actual sensations, and it is exceedingly difficult to differentiate one from the other. Fortunately, from the practical point of view, the sensation and the image serve the same end; and for present purposes we shall use the term "motor imagery" to include the motor sensation in so far as it cannot be extricated from the image, fully recognizing that in one person the image may be more dominant than the sensation of the inceptive movement and in another person this condition may be reversed. While it is convenient for the study of individual differences in vocational guidance to lump these together, this fusion should not stand in the way of keen separation of the two factors by persons who are capable of doing so by introspection for other purposes.

Method of rating. In section III of the general test of imagery above, we have a means of evaluating the motor imagery. The same principle might be extended so as to make a more intensive test if desired. We find the same large range of differences from a record of 0 up to a record of 6 on our scale. But ordinarily motor imagery is rated lower than auditory or visual imagery. This may be due largely to the fact that the visual and the auditory furnish intellectual content, whereas the motor image furnishes emotional content.

IX. Musical Imagination

Music a symbol. Music, like language, is a series of symbols which may or may not convey the desired message. Through creative imagination the composer gives a message to the world, but whether that message shall be transmitted

faithfully and be received effectively depends upon the possession of the right imagination on the part of the performer and the listener; in every case the outer form of music is merely a symbol of the inner feelings, ideals, or ideas of composer, performer, and listener.

Differentiating power of music. As compared with language, music appeals especially to the imagination in that the symbols do not represent discrete ideas. The same music may mean to different individuals, and to the same individual at different times, the graceful rolling of blue waters, the peace of a pious soul, the joy of a comfortable meal, or a sweet and pure feeling of artistic serenity. It is not that music does not convey fine distinctions. Mendelssohn wrote to an author who composed verses for his "Lieder":

> Music is more definite than speech, and to want to explain it by means of words is to make the meaning obscure. I do not think that words suffice for that end, and were I persuaded to the contrary, I would not compose music. There are people who accuse music of being ambiguous, who allege that words are always understood: for me it is just the other way; words seem to me vague, ambiguous, unintelligible, if we compare them to the true music that fills the soul with a thousand things better than words. What the music that I like expresses to me seems to me *too definite*, rather than too indefinite, for any one to be able to match words to it.[1]

Language of music. This quotation involves penetrating psychological insight. Mystical symbols transcend the carrying power of words because they stimulate the creative self-expression and self-objectification of the listener who has a musical mind. It is to the credit of language if it convey one specific idea and that only; it is to the credit

[1] Quoted from Ribot, Th., "Essay on the Creative Imagination," Chap. II, 213.

of music if it lead to a richer self-expression, transcending the bounds of defined concepts and literal form.

Two meanings of imagination. The word "imagination" is used in psychology in two meanings: first, the power of having mental images; second, "the process of forming new ideal combinations, which depends on relative absence of objective restrictions and the consequent freedom of subjective selection." The first aspect of imagination, a mental process in terms of images, as discussed in the foregoing sections of this chapter, is the principal aspect ordinarily treated in the textbooks under the head of imagination. Many of the traits of the second aspect of imagination, as just defined, are held in common with memory, which is often spoken of as reproductive imagination. Indeed, imagination proper is not a specific mental process, as is sensation or perception, but is rather a designation for certain group functioning of images, associations, thoughts, feelings, and efforts in countless permutations. This view does not deny the reality of the process of imagination or in any way detract from its importance, we must give to it a central and dominating place among the musical capacities. But this attitude leaves but little to be said in applied psychology of imagination beyond what is said on the related aspects.

Recognizing the dominance or abeyance of specific traits we find certain types of musical minds: such as the sensuous, the intellectual, the sentimental, the impulsive, and the motor.

The sensuous type. The sensuous type is characterized by luxuriant and realistic imagery, in terms of which experience is created and re-created. Instead of recalling experience in a matter-of-fact way, one endowed with this imagi-

nation at once reconstructs experience in images more or less fantastic, conventionalized, idealized, and enriched, and often so molded as to embody his feelings, biases, and aspirations or fears. He lives in a world of the senses and enjoys a sort of abandon and luxurious freedom from restrictions of the commonplace. It is the life of the impressionist, an effervescent life of the moment, reverberant in sensations and images.

The intellectual type. The intellectual type is ordinarily spoken of as the scientific or philosophical imagination. Creation takes the form of propositions, theories, postulates, and logical ideas more or less concretely and directly represented in images. The sensory and imaginal elements are relatively in abeyance and the process is cool and deliberate. For the reason that it deals consistently with large units of thought, this is the master form of imagination; the feeling involved is placid but may be intense.

The sentimental type. The sentimental imagination, often called the artistic, is characterized by its tendency to idealize experience in terms of the higher sentiments. Objects and events assume meaning with reference to remote ideals, or sanctions, such as harmony, unity, pleasure, or the opposites of these. The world is a world of truth, goodness, and beauty, or their opposites, rather than the humdrum of the common man's experience; experience is thought of in terms of ideals and feelings rather than of events and things.

The impulsive type. The impulsive imagination is that which results in display of feeling and the arousal of the emotion in others. It lacks logic, poise in sentiment, and continuity of effort. It often results in great creations as it taps the deeper resources of life under the stimulus of

great emotion; but it tends to be sporadic and is wanting in cogency and continuity.

The motor type. The motor type of imagination, sometimes called the practical or mechanical imagination, lacks the appearance of mental creation and often suggests the effort of the plodder. It appears in the person whose interests are practical and who can foresee only as he gradually works out situations by doing. It is characterized by persistence in effort, serviceable forethought, and the tendency to achieve practical success.

Other groupings. To these may be added the balanced imagination — that which includes each and all of the type-traits in well-developed symmetry. For further detail of description we may designate various combinations, such as impressional-sentimental; the relative strength may be designated throughout by such adjectives as weak, moderate, and strong. The great musician has developed all of these traits in so far as they are not contradictory or mutually exclusive. The inferior musician may have none to any marked degree. Between these extremes the various cases of musical imagination may be designated quite serviceably in terms of the relative prominence of these commonly observed traits.

X. Significance of Imagination as a Musical Talent

Needed: not tests, but insight. It is possible to put imagination to a variety of practical tests for the purpose of rating. But in musical guidance, it is much more profitable to gather from all available sources of information a sort of *ensemble* picture of the spontaneity and self-expression of the child, noting roughly the characteristic tendencies toward any one of the types which have just been mentioned.

Indeed, the study of the child in this respect is most important because the type of imagination determines the type of the musician. It is extremely important to know whether we shall have a musician of the sensuous, the intellectual, the impulsive, the motor, or the balanced type, and what relative degree of strength it promises. What teachers and guides in music need for their purpose is not tests, but insight into the nature and the manifestations of this gift, which may well be designated as the "spark of genius" in the artistic mind.

Dangers of imagination. A high capacity for imagination may be detrimental. Many musicians make wretched performers because they have no adequate capacity for abstaining from the injection of their own idiosyncrasies into the rendition of a musical selection. They are uncritical and erratic because of an extravagant sensuous imagination, or they suffer the extravagant hardships of the artistic mind on account of excessively impulsive imagination. All such are aberrations.

Musical guidance. For the purpose of guidance in music, then, we must take into account the ratings of these capacities which underlie imagination of various types and note in some serviceable way the tendency toward freedom, originality, effectiveness, and power in the forming of new ideal combinations of musical contents in musical creation, whether it be composition, performance, or listening. These tendencies of imagination reveal themselves early in childhood quite apart from music itself and remain permanent traits throughout life.

CHAPTER XII

MUSICAL MEMORY

I. The Plastic Limit

The view of James. "It will now appear clear that all improvement of the memory lies in the line of elaborating the associates of each of the several things to be remembered. No amount of culture would seem capable of modifying a man's general retentiveness."[1]

The controversy started by this statement of James a generation ago has not yet died down. His statement means that each of us is born with a set brain capacity which cannot be improved by training. And he was right in the same sense that we can say that a farmer buys a certain kind of soil; it may be the richest alluvial soil or it may be the sand of the desert. Suitable cultivation may do wonders with a given soil, but aside from temporary fertilizing, skill in adapting vegetation to the resources of the soil, and the supply of its needs, the original capacity of the soil remains fairly constant in its class. But the superficial critic has said for thirty years: "Behold the fact of phenomenal improvement in retentiveness."

Nature is prolific. The explanation lies in the fact that nature is prolific. Every normal person is born with a brain capacity for memory far beyond what is ever developed. Indeed, it is safe to say that any normal child, or adult

[1] James, "Psychology: A Briefer Course," Holt & Co., p. 296.

beyond middle age, may increase his memory by proper training at least tenfold, and often much more, and still not utilize his capacity to the limit. Such improvement in the use of a given brain capacity is no evidence of improving the capacity; it is nothing but evidence of acquired ability to use the available instrument or capacity.

Capacity *versus* skill. In judging memory we must not confuse native capacity and specialized skill. Most of our exhibitions of unusual memory are specialized skills. Pillsbury, the chess player, blindfolded, played simultaneously fourteen games of chess, two games of whist, and two games of checkers, and carried on a running conversation, while usually winning the games. It seemed to be easy for him and gave witnesses a feeling of uncanny weirdness; yet Pillsbury had only an ordinary memory in other respects. He had used his inborn capacity to most excellent advantage by developing a specific skill for which he had natural aptitude and in which he displayed indefatigable patience.

Memory involves many capacities. Memory is not a single faculty or capacity; it is several capacities, each with definite aspects, and may be developed into countless varieties of ability and skill. Titchener's large four-volume manual of experimental psychology has no chapter on memory. It has chapters on images, association, retention, recall, and related subjects which are specific aspects of memory.

How memories differ. In judging memory capacities, we must, therefore, bear in mind that there is no single measure of memory and that it is possible to measure a great many different functions in memory. Memories differ with reference to the content, as in auditory, visual, logical, or affective memories. They may be organic or

conscious, the organic memories being those which are so deeply ingrained as to have become unconscious in their operation, as in the playing of the score after skill has been acquired; whereas conscious memory is one which operates only under more or less strain of attention. Memories differ as to type of association, as in sensory memory, logical memory, or mechanical memory. Memories differ in various stages, so that a person may be strong in the registering of immediate impressions, in long retention, in accurate recall, in realistic imagery, and other aspects. Memories differ, of course, with training, as every development of skill is the acquisition of an organic memory. In the face of this complex situation of countless possibilities and variables, it is not easy to select one or a small number of memory tests which may be regarded as a reasonable index to the general power of memory in the personal equation of an individual. For an adequate analysis of the memory process the reader must turn to the many books now available in the psychology of memory and the learning process, of which Meumann [1] might serve as a good introduction.

II. Auditory Memory Span for Pitch

Aim of memory tests. In general, memory tests may aim at one of three objects; first, the determination of natural capacity for a particular content, as in the test here described; second, the test of acquired skill, such as the rendering of repertory, or the possession of absolute pitch; and, third, the power of learning, determining the rate and effectiveness of capacity for learning.

Two types of method. There are two general methods

[1] E. Meumann, "The Psychology of the Learning Process," Appletons, 1913.

employed. In the method of reproduction, the observer is required to sing or play or otherwise produce or designate the thing that is remembered; by the method of identification he is simply required to identify memory objects which are presented. The latter is the method here followed because it is by far the most accurate as well as the best adapted for our purpose.

New material. A test which shall be equally fair to young and old, trained and untrained, and shall serve as a single test indicative of natural capacity for memory cannot be a test of special skill. It must employ material which is equally new to all in so far as that is possible — material which may be analyzed, described, varied under control, and repeated so that norms may be established.

Memory span a good index. Everything taken into account, the best single and fundamental test of capacity for a musical memory that we have been able to devise is the test of memory span. Comparatively full directions for this test may serve as an example of procedure.

The test material. The material to be memorized is furnished in the musical notation. There are five degrees of difficulty represented by the five spans. The first half of a measure is called the "first part" and the second half the "second part." The second part is always like the first part except in one note; and the test consists in determining which of the notes, in order, was changed. The listener records 1, 2, 3, 4, 5, or 6, as the case may be, according as he heard the first, second, third, fourth, fifth, or sixth note changed. The distribution of records and the norms of rank for this test are shown in Figs. 1 and 2 respectively.

The most striking result of this test is that a span of 6 is difficult enough for practically all of a normal community.

A person who, in an extended series of trials, is able to get all records right would have an extraordinary capacity for this kind of memory. Other things being equal, the child in the fifth-grade room who ranks 85 gives promise of a memory for as extensive a repertory as any musician may need, and persons who now play programs of several hours entirely from memory may not rank higher than 90 on this scale. Another very surprising thing in the records is the number of bright pupils who fail even on the two and three span, showing that ordinary memory of this kind does not correlate very closely with general ability in school

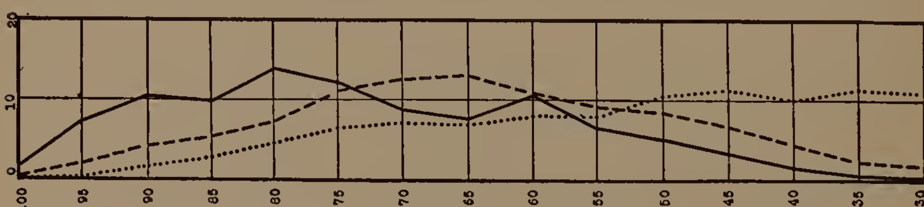


Fig. 1. — Distribution of Capacities in the Auditory Memory Span.

Based on phonograph record A7540.

Figures at the left, per cent of cases; at the bottom, per cent, right. Solid line, adults; dash line, eighth grade; dot line, fifth grade.

work. In the personal interpretation of these records one should, however, take the general intelligence into account because, other things being equal, a dull person is likely to be handicapped so that the spontaneous exercise of memory in music might be better than the record here shows.

Reliability of the test. It may be said in general that the good records are probably reliable because they represent actual achievement. Ordinarily the upper half of the records should be considered entirely trustworthy. In the lower half we find a variety of cases, *e.g.*, those who lack general power of mental application in sustaining effort;

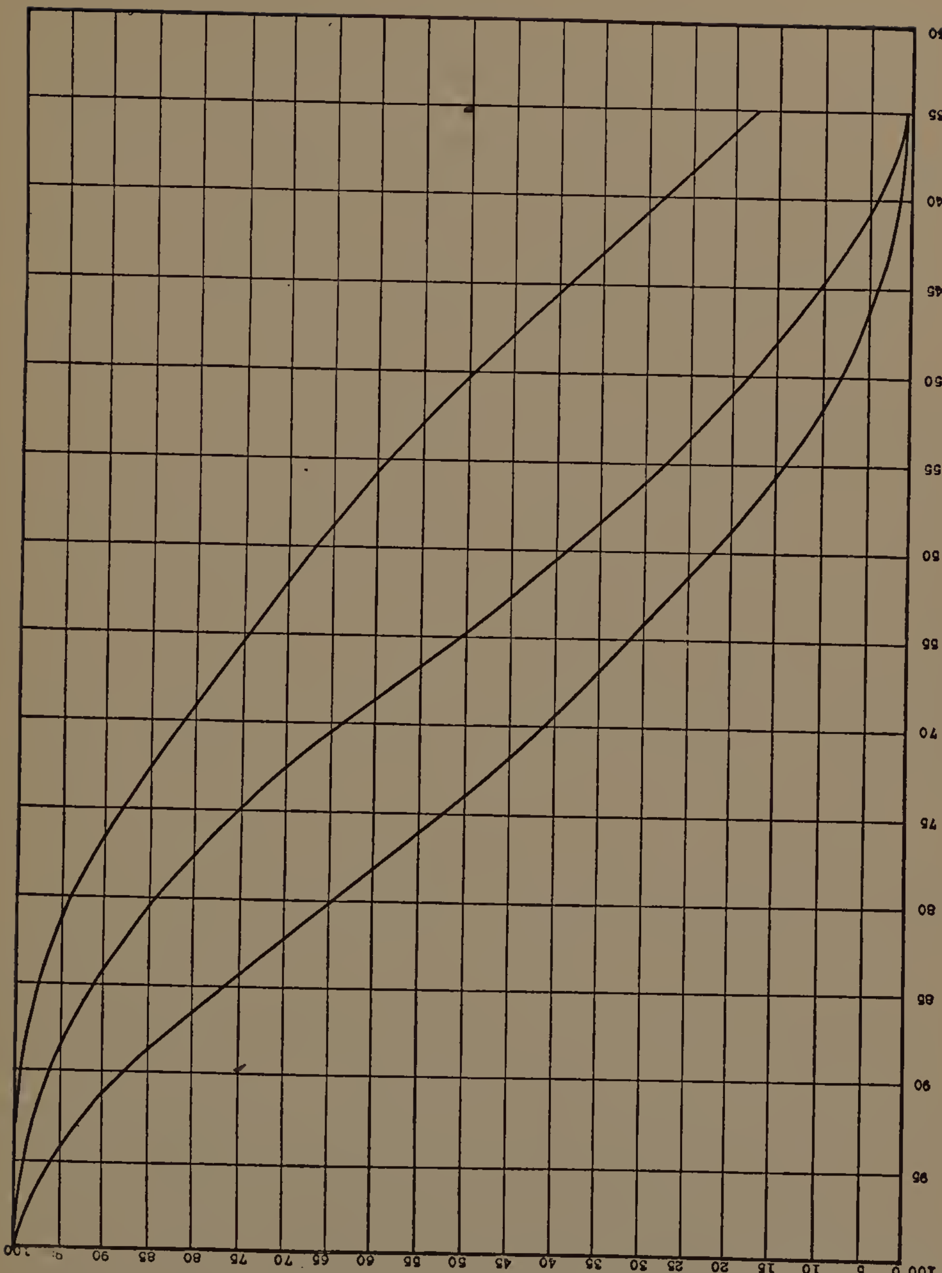


Fig. 2. — Norms for Rank in Auditory Memory Span.

those who may have been disturbed by something occurring in the room; those who may have been lacking in serious effort throughout the test; and possibly others which might be isolated so that in most cases of importance the pupil with poor record should be given an individual trial or trial in small groups, in which it is possible to verify the record or isolate the sources of error.

Effect of training. Memory is capable of cultivation on a large scale. The memory skill of any one in the plastic period might be increased at least tenfold, but the significance of records of this kind comes from the fact that they are marks of natural capacity. They show with what sort of raw material the memory training starts. The improvement will be roughly proportional to the original capacity; *e.g.*, if we have the capacities represented by the 10 per cent, 50 per cent, and 90 per cent ranks respectively in three cases, the improvement is not going to make them any more alike than they now are, but will increase the difference in geometric ratio. Other conditions being equal, those with a large capital will improve, not only in proportion to their capital, but probably in increasing proportion for the larger capital.

No vocational guidance in music should be based upon this test alone, and conclusions as to ability must be limited to the factors under control, namely, immediate memory for unrelated tones.

Factors under control. In this test it will be observed that we have controlled the memory content, namely, pitch. We have controlled the rate at which the tones are given, the duration of the tones, the number of tones, the tone quality, the directions given to the observers, the method of reporting, and supplementary aids.

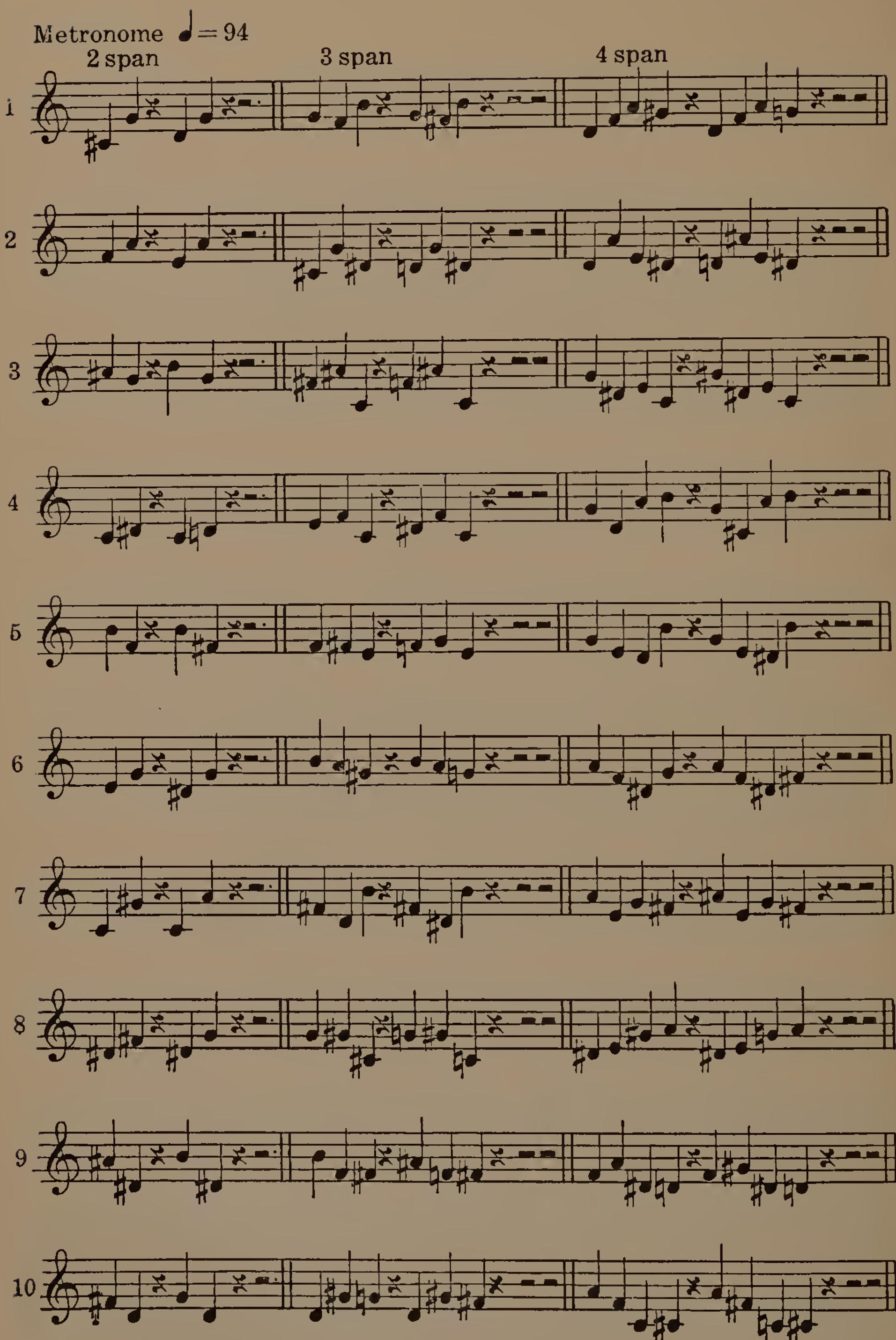
The same kind of test might be made with musical time, or musical intensity as the memory content; but pitch seems to have the larger significance and is the most easily available.

III. Retention

How to measure retention. The foregoing was a test of the ability to grasp a given content for immediate reproduction. It is evident that, if one is not able to get the impression in this span, he will have nothing to retain; but those who have a good memory span vary in their ability to retain. The power of retention may be tested with the apparatus suggested for the sense of timbre. A synthetic tone is built up, say from five tuning forks in a harmonic series transmitted through a telephone, as directed in Chapter VI. This complex tone may be varied in timbre by varying one overtone systematically. The advantage of using a synthetic tone of this kind is that no one has any name for it; it has to be remembered as a tone, and it can be dissected and varied at will. After having sounded this tone for a few times until it has been learned, we may wait for a certain number of hours or days, and then sound this tone with other tones varying in timbre by certain stated amounts, making a large number of trials and requiring in every case that the original tone shall be identified. As in other tests the record may be kept in terms of per cent of right judgments. The same procedure may be followed for any other tone material.

IV. The Learning Curve

A quantitative record of rate of learning. Memorizing is learning. It is manifestly of great importance to a parent


Metronome ♩ = 94
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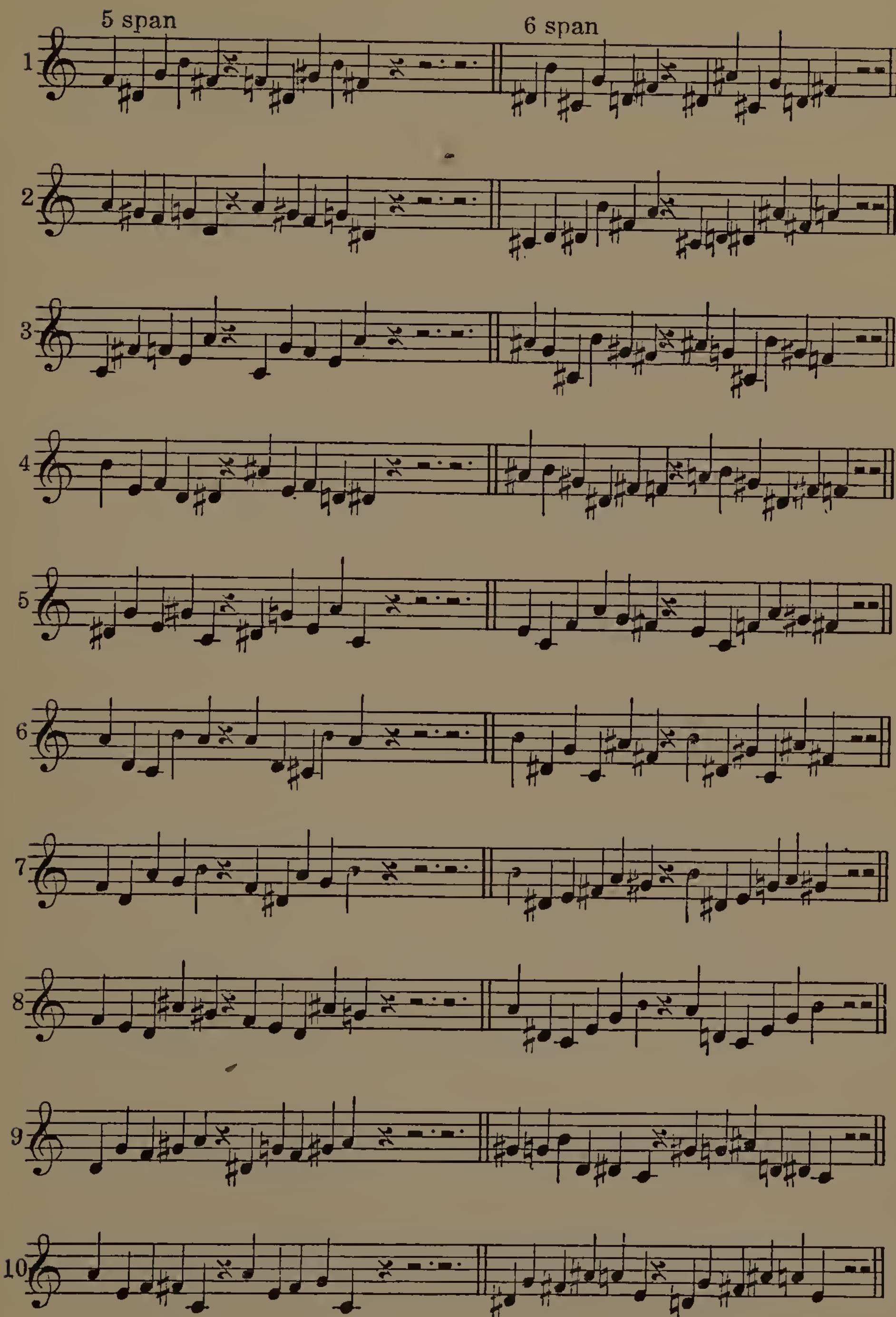
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to know whether or not a child who is going to enter upon a musical career has a 5 per cent rate or a 95 per cent rate in learning capacity. The cost of the investment, the satisfaction, the promise of achievement, all hinge upon this difference in native capacity for learning. It is possible to determine the probable "learning curve," or rate of learning to a fairly high degree of accuracy before the musical education has been begun. It can, of course, be done roughly by giving the child a music lesson or a series of lessons to see how long it takes him to learn it; but there are technical procedures which are very much more accurate and comprehensive.

The "curve." The learning curve is a graphic representation of the rate of the acquisition of skill in memorizing. The height of the curve above the base line on any day indicates the amount of achievement. We start with a given ability of 5 per cent, 20 per cent, or 45 per cent, on the first trial of a new test like this. By plotting the achievements of the first few days in actual experiment, we shall establish as many points in the learning curve of the individual and thus be able to predict his probable rate of learning of the type employed.

Test material in music. For material, we might be interested in determining the prospect of progress in sight reading in playing the piano. The test might, of course, be made with an actual piano and actual music. In that case the material should be standardized very carefully and fitted to the pupil's degree of attainment; the material should be made up of a number of small units of approximately equal difficulty, but all new. There is an advantage in allowing each music master to use his own ingenuity in the employment of testing material at his command.

The test must, however, be organized in the light of knowledge of experimental procedure. The ordinary music lesson would not meet the needs; but musical material may readily be converted into test material. This principle may, of course, be applied to the testing of any aspect of playing. It may also be applied to problems in the theory of music.

Applicable to any factor. In the psychological laboratory it is possible to set a variety of training conditions which can be controlled more accurately and we may realize results in a shorter time. One type of measurement on the ability to learn may be illustrated. In training to sing in true pitch, Knock[1] gave twelve university students (women) the following test. They were given five half-hours' exercise in singing the keynote, the major third, the fifth, and the octave. All tones were registered on the tonoscope. They were thus given ten periods of training in the same interval with the tonoscope, the ear being corrected by the eye in every trial as described in Chapter X. To determine how much they had profited by the training with the eye they were again given five periods of singing without the aid, as in the first instance. Let us designate the three groups of training as, before (I), training (II), and after (III). The results, averaged for the twelve singers, are

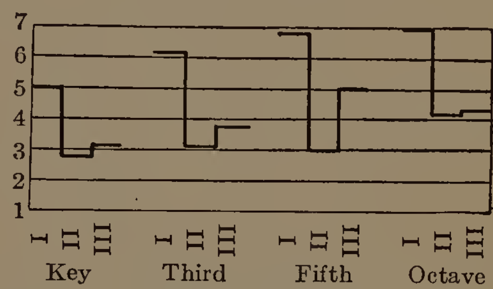

Fig. 5. — Achievement in Training the Voice by Aid of the Eye.

The amount by which III is lower than I in each section indicates the amount of net gain by a given amount of training. The figures at the left express accuracy in terms of vibration.

[1] Studies not published.

shown in Figure 5, which designates the achievement in terms of average error before training, in training, and after training. By taking a sufficient number of cases in this way we may establish norms for these three stages. The progress of any other individual may then be measured in terms of such a norm.

This record must be accompanied by a record of pitch discrimination; for, if the pitch discrimination is, for example, 5 d. v., and that ability in singing has already been reached, there is scant chance for further improvement, the impediment being on the sensory side; whereas if the pitch discrimination is $\frac{1}{2}$ d. v. and the average error of 1 d. v. in singing has been reached, there is splendid promise. In a similar manner many other factors may be isolated and taken into account in an analysis of the factors which make for gain in practice.

Learning the chromatic scale. Another test of the same kind would be to measure on the tonoscope the acquisition of ability to sing the chromatic scale. Nobody is perfect; but with the tonoscope we have very exact means for learning how to improve ourselves and measuring the improvement. The rate of learning should be determined with reference to whatever aspect of music the pupil is going into. Singing and violin, for example, require quite different tests.

V. Absolute Pitch

Nature of absolute pitch. Many musical people to-day speak of having "absolute pitch." But when we come to inquire what is meant by absolute pitch, we find that it varies through all sorts of degrees, from the ability to name a note when struck on the piano without reference to any

other note to the ability to tell when the violin is tuned $\frac{1}{10}$ vibration too high. The ability to name notes of a familiar keyed instrument on hearing a single note is rather common among trained musicians and may show itself very early in childhood, even during the first year of acquaintance with the instrument. No thorough experimental work has been done on the subject, but there are indications to show that it is not absolute pitch which is kept as a standard in memory, but rather the timbre of the note. If we run through four or five scales on the piano it will at once be apparent that, regardless of pitch, no two notes sound alike. The timbre of the low notes is entirely different from that of the higher notes, and the evidence seems to show that it is easier to remember a characteristic timbre than pure pitch in itself.

How to measure it with pure tones. Pending an experimental investigation of this question, any one who possesses the power of recognizing absolute pitch may not only measure it but also secure some evidence as to its basis. To measure absolute pitch, let the experiment run for some months, devoting a minute or two to the test each day, in the morning before any other musical sounds are heard, as follows: Use the above set of pitch-discrimination forks, Figure 5, Chapter II, with the resonator producing pure tones. Sound the standard on the first day until it is thoroughly familiar. On the second day sound one fork — either the standard or a differential fork — and require the observer to say whether this tone is standard or a higher tone. Then sound the standard in preparation for the next day. Repeat this procedure on successive days until each of the differential forks has been sounded at least ten times. The record will then show what is the smallest

pitch difference that can be heard without error when the compared tones are a day apart.

With rich tones. In this test timbre is eliminated, because the tones are pure, and any ability shown will be a memory of pitch, pure and simple. But, to make the test under the conditions that absolute pitch is usually exhibited, we should use rich tones such as those of the piano or violin string. The most convenient means for this purpose is a carefully tuned monochord if played by one skilled in the handling of the bow. In psychological laboratories we have other instruments well adapted and graduated for this purpose, such as Stern's tone variator and Spearman's dichord. If the theory advanced above is correct, a very much better record should be made with a rich tone than with a pure tone.

A precaution. It is evident, of course, that the naming of one or more notes after one has been successfully named is not absolute pitch but relative. It is quite certain that absolute pitch attaches by preference to some particular note and that any other note heard is readily, quite automatically, identified with reference to this standard note.

Significance of absolute pitch. Much might be said about the advantage of absolute pitch and the peculiar satisfaction it gives. It is not only a convenience to the teacher, but it is a source of pleasure in itself in creating a feeling of familiarity and mastery in tonal environments. This feeling is enhanced by the fact that absolute pitch is usually present only in persons who have highly developed general powers in the sense of pitch, and these in turn lead to high powers in the appreciation of pitch complexes in all the richness of musical and unmusical combinations.

VI. The Significance of Memory in Music

Nature of the situation. A good memory is not necessary for the appreciation of music; although of course a person misses what he does not remember; and there is a definite loss, not only in the fact that he cannot enjoy the thing that is forgotten, but more particularly because he cannot utilize a forgotten experience, and therefore will fail in self-improvement and self-expression to that extent. But more significant than the memory of melodies and harmonies is the discriminative memory for fine distinctions, as, for example, the ability to recall with precision many fine shades in timbre and tone production, the ability which we might call presence of mind in singing and playing as well as in listening, the ability for creative imagination to foresee accurately the results of certain remembered conditions. Back of all these is the effect upon feeling; for feeling is a reverberation of mind and body as a whole in response to the present setting in its past relationships. The feeling will be one of the sensory memories to the extent that an accurate organic memory of the relationships of the past is present. The most concrete aspect of shortcomings in memory is, of course, in the learning process. It there becomes a matter of rate of learning which involves matters of economy, available lifetime, patience, optimism, and a feeling of achievement which is an essential ingredient in self-respect, self-confidence, and the will to live.

Educational bearing. Often parent or pupil comes with certain misgivings as to the chances of achievement. A wide-awake teacher will not proceed blindly merely to train, but will analyze the situation and make plans on the basis of forecast. The assembling of data bearing on the various

capacities which are prerequisite and the actual testing of promise as to rate, reliability, and compass of progress can do much to avoid mistakes, lessen expense and suffering, and direct and guide the pupil to his highest level of achievement. It is, therefore, extremely important that the teacher should have a fair technical knowledge of what memory is in order that the fortes and faults of the pupil may be appraised, if not by quantitative measurement, by the first evidences in actual pursuit of the musical training.

CHAPTER XIII

MUSICAL INTELLECT

I. Introduction

Music an expression of the intellect. Although music is not essentially a logical medium, its character varies according to the relative kind and degree of intellect of which it is an expression. The thought processes in music may take a great variety of forms and tendencies and will, of course, vary in degree. It is possible for a person, strong in other capacities, but with relatively low intellectual power, to assume fairly important rôles in music within restricted fields of activity; but the great musician is always a person of great intellect.

Thinking in music. To point out shortcomings on the intellectual side of even a great musician is easy. He may be poor in mathematics or in theory of science and yet be a great thinker in music. There have been renowned mathematicians who were quite incapable of mastering the subject of grammar. Musical thought is a specialization in dealing with the problems which arise in music. Although the form and content of the thought are different, it requires the same kind of logical grasp as in mathematics or philosophy. The mathematician is not necessarily a philosopher, and the philosopher is not necessarily a mathematician, but both are thinkers. Likewise, the musician may be a good thinker without being a philosopher or a mathematician.

The musicians' thinking outside of music. We should not overlook the fact that it is a matter of no small consequence for the art whether or no the musician has any intellectual interests outside of his art, because it is the presence or absence of these that in a large part determines the stability of personality, balance of judgment, and catholicity in tastes, as well as insight into nature and art on a large scale. The ability to see the inter-relationships of art and the ability to understand the operations of the human mind are, perhaps, the best logical supports for thought in music.

Intellect *versus* information. We must not confuse or identify intellect and information or learning. A person of relatively low intellect may amass information; and intellect in the form of natural capacity for sustained idealism, judgment, and reasoning, is often dominant and very active in a person quite untutored. For musical power on a large scale the latter is the more valuable. It represents power, whereas the other represents storage goods.

For the present purpose we may distinguish three general marks of musical intelligence: first, the characteristic of free association or musical content; second, the power of reflection; and, third, general intelligence.

II. Musical Free Association

Free associations sample mental content. Thinking is the elaboration of ideas in the mind to meet new situations and to solve new problems. Our first question with reference to a given mind is, therefore, What musical ideas hover in this mind? The question may be answered by taking a sort of cross section of consciousness at a given moment as a sample of the mental content in order to discover what

ideas are its stock in trade. To illustrate, suppose we ask a miser, an inventor, and an artist, each to start at the signal word, "clock," and to speak instantly, as fast as he possibly can articulate the words without thinking, the first ten words that come to his mind. Any one can predict certain differences that would come out of these lists if they were faithfully reported. Each man would, in the long run, reveal his character. This free association test depends upon the principle that the word shall be spoken so fast that there shall be no time to consider the fitness of the response. When this is done, two traits are revealed: one is the kind of information the person has; the other is the bent of mind.

In children. While a child of five or seven has not acquired much formal information, his mind is already stored with that kind of content for which he has a natural bent, and indeed the sample of mental content at that age is perhaps a clearer indication of the situation than it would be later for the reason that the child of this age is spontaneous and reveals his real nature, which has not yet been set by any educational forcing. Make it a game with children — and a very interesting game it is to catch their images and ideas on flight as they pass in review very much more rapidly than they can be named. One good way is to stop the child after he has spoken five to ten words and ask him to fill out the words which he did not have time to speak but which came to his mind, or to describe the imagery to which the words are merely a label. In this test natural impulses will be revealed in an astonishing way, often much to the embarrassment of the subject. It is not a formal test and should not be used mechanically. Technical training in the use of this test prepares one for accomplish-

ing the same thing in a more natural way in ordinary conversation and intercourse.

In easy conversation. Any cultivated musician conversing for a half hour, entirely free from the conventions of making talk, with a musician or prospective musician, will form a fairly accurate notion as to what is naturally and effectively in his mind — what logical material he actually has at his command. This is even easier when the subject wishes to seem to be something which he is not, as in labored sham, or acquired affectations, or the influences of fads, fashions, and cults. Indeed, the more he labors to conceal his true character, the more certainly he reveals it — just as we have recently found that the *camouflage* of the Germans was so systematic that it was comparatively easy to know what was being covered. The observer will, of course, always take into account age, training, environment, information, temperament, and other factors which determine what shall be uppermost in our minds. The procedure is very simple and direct.

Bent of mind. Musical content lies ultimately in an intellectual bent of the mind toward musical appreciation, expression, and creation, rather than in the information a person has in music. What we wish to know is, whether or not his intellect is of the musical type, as distinguished, for example, from the intellectual, the scientific, the philosophical, or the literary type in its free association responses.

III. General Intelligence

Common sense. Mr. Hotchkiss, the custodian of the Yale campus, once made a speech to us students, apropos an act of forgetfulness of one of the professors, saying that he wanted to establish a chair of "common sense," but

had failed to do so because he could not find any one fit to occupy it. With a hearty good Yale cheer, we proceeded by acclamation and voted Mr. Hotchkiss Professor of Common Sense. Perhaps common sense is not held exclusively by janitors and others not holding positions of learning. Common sense comes near to being general intelligence; that is, a natural ability for dealing with new situations reasonably. The janitor was right in assuming that general intelligence may exist quite apart from learning, and that it is not merely a matter of information.

Intelligence rating in music as in army. We have now a mass of intelligence-tests, all based on the idea that a person with general intelligence is one who can cope effectively with new situations reasonably within his grasp. The most notable use of these at the present moment is in the recent method of rating men in the army as to their fitness for various positions and as a basis for promotion. Promotion of officers on the basis of seniority, though sustained by the sacredness of its universality and age as a tradition, is a method now relegated to the scrap heap. One preëminent element in merit is general intelligence. So in music, the music school of any consequence in the future, like a few rare examples at the present time, will extend its privileges, not in the order of application, nor at the rate of willingness to pay, but on the basis of merit; and one far-reaching element in musical merit is the general level of intelligence.

General intelligence an inherited talent. Musical people have been known to be rather severe in their criticism of associates in terms of the kind and degree of their general intelligence. The point which we wish here to emphasize is that the schools do not have the power to generate this

type of intelligence where nature has not herself placed it, and the presence of such capacity may be discovered in any child by the trained observer before the child is old enough to begin the study of music seriously.[1]

IV. The Power of Reflection

Sustained attention. According to Dewey,[2] reflective thought is "the active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of grounds that support it, and the further conclusions to which it tends." Given the raw materials in the form of ideas and images dominant in the mind, their intellectual significance depends upon the power of reflection, the power of sustaining the focus of attention upon ideas in such a way as to penetrate into the ramifications of their relationships, and thereby elicit new ideas.

Need of reflective thinking in music. The necessity for reflective thinking in music is found in the necessity for understanding the principles of art, the necessity for penetrating into the human emotions which are to be swayed, the necessity for comprehending something of the principles of physics, physiology, and psychology of tones, and the desirability of conceiving one's musical world as a part of a larger world view.

Thought precedes automatism in music. Too many musicians find a cover for the absence of the power of reflection on the theory that music is an impressionistic art; it cannot be reasoned out; it must be felt and allowed to

[1] The matter of intelligence tests now constitutes a large branch of psychology in itself. A good elementary presentation of the subject is found in Terman, "The Measurement of Intelligence," Houghton, Mifflin & Co., 1916.

[2] John Dewey, "How We Think," The Macmillan Co.

flow spontaneously from the fountain of æsthetic impression, they say. This view of music is supported by psychological analysis; music must flow as an inspiration from a soul full of music in the artistic attitude, which means the welling up of the unconscious forces. The most genuine appreciation and the richest expression of music does not arise when impeded by a technical consciousness, when hampered by thought of principles, rules, and restrictions. Music is an impressionistic art and cannot be created, performed, or most deeply appreciated in the spirit of formal reflection. The psychology of that fact is this: one must have been intensely conscious of technique, must have known laws, must have isolated element after element for intensive study, all severely intellectual, cold, and quite free from the artistic impulse, before control of these can become so automatic as to drop into the background of consciousness.

Bearing on teaching. While we are not here concerned with the pedagogy of music, it may be in place to point out that in this principle of transition from focal consciousness to grace and skill in automatism lies a most fundamental principle of teaching. It implies that, in vocal as well as in instrumental teaching, we should make incisive attack on one feature at a time and insist upon critical and accurate detail through the focus of attention. Free singing and playing for present pleasure and self-expression should always be encouraged, but this should never be an excuse for dawdling, ignorant, aimless, uncritical and mystical work in training. Assuming a musical background based upon contact with music, the pupil in developing a musical technique should begin with the simplest detail and observe it critically at his level of thought and skill in order that he may acquire discrimination and precision. These acquired

in one detail, attention may be diverted to new conquests. As matters of technique are thus progressively made secondary and relegated to the subconscious, the mind is free to launch itself upon the ideas and ideals to be conveyed.

A related illustration. In this respect music is not much different from any act of skill; take the simple act of tipping the hat as described by the author elsewhere.[1] "When the boy is to learn to raise his hat he should be free to acquire the feeling that the raising of the hat is a sign of good breeding; that it is an honor to himself and to the person greeted; that it gives a delightful feeling of satisfaction in power and self-mastery; that it goes well with a smile and a compliment; that it brings returns; that it is a means of relieving pent-up energies by knowing how to dispose of the hands; that he can thereby actually express individually his appreciation of the person greeted; that raising the hat is not that trifling physical act alone, but, when properly done, is the entering of one mind into relation with another; that this little act of manners is a part of the making of the man; that if he does this with all his heart he will acquire the power to do greater things with the same ease. This implies ability to hesitate, and to gauge the situation in his own mind; it means willingness to cope with instinctive cravings; it means willingness to fight single-handed for personal adjustment. All this tends to throw him into an attitude of profoundest consciousness of this act for the time being. At this beginning of a new adjustment it is well that he should be free to think, feel, and act with the most absorbing consciousness. But, as soon as he has learned to raise his hat, that process should take care of itself, should be automatic, so that the act is performed on

[1] "Psychology in Daily Life," Appletons, 1913.

every appropriate occasion without hesitation and without consciousness of conflict, but with the fullest richness of significance. Only when the adjustments are once made through the most strenuous consciousness or self-acting will his consciousness be free for new operations, for the making of new adjustments."

Thought precedes inspiration. But the greater the art, the more necessary it is that there shall be as a groundwork for the spontaneous creation a skeleton of logical information and insight in regard to the nature and laws of the structure which is to rise. The great artist has thought and lived great thoughts a long time before they break out in melodious harmonies. But these thoughts must have become second nature to him; the rules of thinking must have become easy; the principles of composition like the laws of the land must be so obvious that he will not violate them. When his mind is free from all these, his spirit can be poured forth in a creation which will be an expression of his ideals.

Intellect dwarfed by neglect. Much of the opprobrium which attaches to artists as a class rests on the fact that the artistic attitude is one of intense sensitiveness and sentimentality, which develop an atmosphere of exclusiveness and result in the loss of that leveling influence which comes from common contacts in the humdrum of life. The power of musical reflection is often dwarfed in artists by cultivated affectation of sentimentality which becomes so ethereal and flimsy that the logical mind suffers as the body of the artist does if it tries to live on faded rose leaves.

Summary. The logical demands upon the composer are self-evident. Each man composes according to the caliber of his mind. Music does represent ideas, great ideas — so great that, like the poet's ideas, they are too

expansive to be expressed in prosaic words. They come to the composer as an illumination, but the great artists in music have agreed with Edison that illumination like invention means infinite capacity for work. Yet work will be of little avail unless there is "grey matter between the ears." Great feelings are the mass effect of an understructure of great thoughts.

V. Musical Significance

Each in its right place. No result of an intelligence test on a normal child should exclude him from music, but the diagnosis of musical intellect for the purpose of direction in music assumes several aspects. First, it should be a factor in determining what kind of musical instruction and opportunities the child should have. There are important outlets in music for the child of comparatively low intelligence, if he be endowed with other musical talents. Just what the music should be depends upon what the prominent talents are, their relationships, and the facilities available. Each case is one of its own kind. The pupil is at the mercy of his teacher. The point on which we must insist is that teachers and parents are responsible for exercising reasonable intelligence and judgment in leading the child into that kind of musical training which is most fitting for his natural intellectual scope and equipment. A child may have a beautiful voice, a fine ear, a reasonable motor control, and yet not have any reasonable chance of carrying a heavy rôle in music; for, in music as in wrestling, other things being equal, a featherweight will be at a disadvantage. We must guide in the light of the fact that the composer must be a thinker before he can become a composer on a large scale; that the interpreter must be capable of thinking

the great thoughts of the master before he can re-interpret them to himself or convey them to others; and that the listener hears nothing beyond the message that his own mind can create upon the sensory cue.

Praise and blame. In judging achievement and in extending praise or blame, it should always be with due cognizance of what the musician is. Is he a mere tone colorist? Is he rich in fancy? Is he a faithful plodder? Is he in command of deep emotion? Is he a master of logical structure in rhythm and harmony? Then judge him on his merits. This is of vital importance for musical pedagogy, particularly in the directing of the young, because we shall not make satisfactory progress unless we find the child in a field in which we can justly encourage him. And we must have the good sense not to hold him responsible for, or attempt to force upon him, powers with which nature has not endowed him.

CHAPTER XIV

MUSICAL FEELING

I. The Approaches to Feeling

Place of experiment. The experimental psychology of music has very little to offer in the way of objective rating or measures of the experience of feeling, its emotional expression, or ability to convey feeling through art. Its main contribution to this subject lies in the introduction of a critical attitude and the recognition of the relations and inter-relations of feelings with other processes. The experience and the expression of musical emotion is an activity of the organism as a whole — every fiber and function. It is possible to record the effect of music upon the respiration, circulation, many forms of internal secretion, reflexes, attitudes, and many other aspects, but we never have feelings or emotional reactions under control for adequate experimental conditions, nor is that to be desired in applied psychology. The psychology of musical talent is based on a frank and consistent recognition of the fact that feelings may be traced to antecedent conditions and stimuli which may be observed and recorded, and that feeling is the result of the possession of capacities, many of which we have learned to analyze, to evaluate, and often measure.

Sources of feeling. Feeling arises from the same source as knowing, from which it is distinguished largely by the fact that the impressions are not differentiated; they do not

take the form of discrete sensations, images, or ideas. The mass of sense-impressions which constitute the groundwork of feeling arises largely from three sources. Of the first class are the impressions from without, such as odors and sounds, all of which carry an affective tone of agreeableness or disagreeableness that may or may not gain conscious recognition. Of the second class are the impressions from without, such as feelings of strain, pressure, and pain. The third class embraces the effects of organic change in the various systems of the body, such as create a general tone of well-being or ill-being of the system, indicative of modification of secretion, circulation, and metabolism, and affecting the nervous system as a whole. The general rule is that when these impressions are not raised to the level of percepts they fuse into one grand mass of experiences which we call feeling. This mass of impressions is modified by memory, imagination, thought, instincts, habits, and impulses, and other mental activities. Indeed, feelings often originate in these higher and more remote mental processes. Therefore, so far as feeling is musical, it comes directly or indirectly from the musical impressions of the senses, whether these impressions are present to sense or are stored up in memory and reproduced in images, elaborated in thought, perpetuated in instinctive tendencies, or have merely resulted in the modification of organic functions. This being so, all analysis of musical feeling must begin by taking stock of the sources of musical impressions.

Feeling rated on capacity of sources. It is a fundamental law of biology that the possession of an organ carries with it an instinct to use that organ. Animals with wings, fly; with fins, swim; with claws, scratch. Applied to the psychology of feeling and expression of musical emotions,

this principle implies that, other things being equal, an organism sensitive to pitch, rhythm, and time, endowed with serviceable imagery, memory, and imagination, set in an intellectual bent of mind associated with a normal physique, is practically certain to respond to music with an emotional glow which shall reveal these capacities. It is equally certain that, if any of the basic capacities are atrophied or inhibited, the emotional expression will be inhibited or distorted to that extent. No one has emotions for impressions which he cannot perceive, and rarely ever for actions or ideas which are not within his reach. We shall, therefore, have a very serviceable picture of the prospective emotional equipment for music if we have an objective record of such capacities as those just mentioned. To the extent that it is comprehensive, such a psychogram representing all the various talents should, other things being equal, characterize the musical feeling and emotional expression of which the person is capable. As to content, feelings dominate in the realm of time, pitch, and intensity. A well-rounded feeling radiates in all these three contents, but as a rule we characterize the feeling by its dominance in one or more of such aspects. The realism of the feeling depends upon the extent to which the object is concretely re-lived as in auditory imagery, motor imagery, and the imagery of other senses. Our feelings pertain to our capacities for doing. The high soprano and the deep bass have peculiar feelings attached to the hearing of singing within their respective ranges. The person who cannot himself hear or keep time is not disagreeably affected by bad time, and is not moved by fine achievements in musical time.

The "pleasure-pain" theory. This fact that we must characterize a person's feelings in terms of various capacities

upon which they rest is further emphasized when we realize that qualitatively there are only two kinds of feelings, namely, the agreeable and the disagreeable. The feeling of agreeableness experienced from a beautiful sunset, a dish of ice cream, or a kind word, is the same. It is agreeableness which results in attraction. The difference is in the knowing process or action — the sunset, the ice cream, or the kind word, and the appropriate action in each situation. Likewise, the feeling in tasting quinine, in failing to pass an examination, in hearing of the death of a friend, is the same; it is a disagreeable feeling. The difference lies in the knowing process, and the action involved — knowing the quinine, the examination, or the news, and the appropriate act in each case. There is danger of confusing feeling with these larger aspects of knowing and action which are always involved in feeling. Ordinarily there is a vastly complex and rapid oscillation between these two types. Richness of feeling consists of an infinitely complex intermingling of the attitudes of attraction and repulsion massed together in the awareness of likes and dislikes. All mental processes are in some degree agreeable or disagreeable.

Bases of classification. Space does not here permit a classification of feelings. They may be classified in a great variety of ways, depending upon the purpose to be served, as for example, according to their origin, making a sort of genealogical tree; according to the mental level, as in recognizing sensuous feelings and intellectual feelings; according to the purpose that is served, as in the feelings of self-defense and feelings of aggression; according to the stimuli which arouse them, and in many other ways. For the purpose of guidance in music we may obtain a general estimate of a person's endowment for feeling if we center our observa-

tions on three points: musical taste, expression of musical emotion, and the power of conveying musical feeling to others.

II. Musical Taste

Standard relative. Musical taste is a sort of general indicator of musical feeling. But taste in music, like good taste in other things, is a somewhat elusive factor. There is no standard of beauty, for beauty is a progressive and ever-advancing goal. It lies in reference to ideas, the ideas of each and every one, no matter how humble and crude. Yet in judging taste we tend to judge it from the point of view of those who have had superior advantages, and, as the science of æsthetics develops, we gradually acquire reasonable explanation for such progressively developing standards.

Taste deeply ingrained. Good taste is actual evidence of æsthetic judgments, but it must be more than that. It must be so deeply ingrained in the system that it represents the natural reaction as distinguished from something striven for and lived as a make-believe. Provided that there is reasonable outlet for the expression of natural gifts, it is easier to determine good taste for music in the young child than it is to identify it in the polished musician. Taste needs to be educated, but unless the natural good taste exists in the organism, the education will result in a sham and in superficial formalism; for good taste is not something put on, or put in; it is something which grows out from within, provided a reasonable environment is furnished.

Æsthetic taste little cultivated in America. This contention is no discouragement to the education of taste. On the contrary, our psychological view of the beautiful

enables us to see how taste, the æsthetic in our nature, is a grievously neglected aspect of human nature. Looking at it from the standpoint of the conservation of human energies and resources through education, we find in our American life to-day that the bodily self, the moral self, the social self, and the religious self, are on a fair way to due recognition, and the intellectual self is over-developed in our schools; but the æsthetic self is yet in a state of nature, quite unrecognized and very much dwarfed. The very fact that we display art is a sign that it is novel to us and has not yet found its place in our natural life. In no art is this more true than in music.

III. Emotional Expression in Music

We find in music as in any other field of activity that certain devotees carry their emotions in an intense glow on the surface, whereas others conceal the deepest feelings under the cover of coolness, self-control, culture, and stability. Therefore, while there is no real music where there is no emotion, and there is no emotion that does not express itself, we should be warned against placing a premium on the crass, outward display of emotion whether voluntary or involuntary. It is often thought that the lives of the scientists, philosophers, and inventors are unemotional; but the fact is that as men are capable of dealing with large units and sustaining attention and effort in a prolonged process of creation, their emotional thrill is proportional to the magnitude of their intellectual achievement; it is so deep and sustained that it cannot be measured in terms of the ripples on the surface. The same principle applies to music. The greatest emotions roll in the longest and deepest waves. Much that passes as warm emotional

expression is, like giggling, an abnormal or diseased condition indicative of instability or disintegration. Musical feeling may express itself, therefore, in the placid tranquillity of an enraptured soul or in the sporadic outburst of an uncultured emotion, in the calm and steady roll of the masses over the deep or in the frothing, roaring, splashing surf of the shallows. Between these two extremes we find all degrees of transition. In judging musical expression of emotion, therefore, we shall be safer if we judge it by the depth and magnitude of the musical organism as a whole rather than by observed ripplets on the surface.

IV. The Conveying of Musical Feeling

Three conditions. The capacity for rendering music in such a way as to convey musical feeling to others rests upon three conditions: the possession of a genuine musical feeling on the part of the performer, a serviceable organism on the side of musical action, and acquired technique. The first two of these are in a way a measure of the promise of power in the acquisition of technique.

Significance of other conditions. The power of artistic expression in music also lodges in large part in various personal powers quite aside from music, such as an equable temperament, healthy-mindedness, personal charm in social intercourse, comeliness of body, and physical health. Great achievements on the intellectual side tend to balance a man, whereas great achievement within narrowly emotional performance tends to distort perspective; an emotion, being a relatively severe drain on the nervous energy, weakens the power of self-control and produces an abnormal sensitiveness. Many successful artists have been notorious for their violation of these homely virtues. But we may

well meditate on how much greater their charm would have been if they had not been sick-souled sufferers from aberrations. The principle remains that a musician who is well physically, morally, and mentally, who has a good disposition, and who is socially attractive, reasonable, and well-balanced, has the advantage over the warped personality, and should represent our goal.

CHAPTER XV

THE INDIVIDUAL AND TRAINING IN THE ART

I. A Self-Examination

The fruit of psychology of musical talent. Applied psychology is quite useless unless it produces results. Theoretical psychology is like physics, a study of principles for their own value. Applied psychology is like engineering (applied physics), valuable only as it serves; the design of a bridge is of little value unless it is followed in building the bridge. A study of musical talent should result in a searching inquiry into the bearing of the facts upon the personal issue and should lead to appropriate action.

Child adjustment the sequel to child study. The child study movement, which began but little more than a generation ago, resulted in the discovery of the child as an individual. The sequel to this movement, which is laying the foundations for modern scientific pedagogy, is developing in our generation in the tendency to take scientific account of that discovery in the guidance and the education of the child. This movement reaches out not only to education in the schools but also to training in the home, provisions for self-expression in play and occupation, care for the unfortunate, preventive medicine, the conservation of human talent, and in particular the recognition of the opportunities and responsibilities for giving the talented child a chance. The movement gathers around the principle which may

appropriately be called the first principle of educational psychology: *Adapt the training to the nature of the child.*

A searching personal inquiry. Lest we give too ready assent to this proposition, let us make it a personal matter in the form of a self-examination of ourselves as teachers, patrons, and pupils in music. Let the teacher make a searching inquiry into his own situation and answer some personal questions for himself (and, if he is so disposed, rank himself on his answers). Grant the patron and the pupil the privilege of participating in this rating. With humble apology for the directness of the questions the author withdraws into the background except for the purpose of making the questions full-faced and explicit. The stage is for the action of the reader.

1. Do I fully realize the magnitude and significance of individual differences in my pupils?

The stern facts. The mission of the present volume is chiefly to put into concrete and often quantitative statements some ascertained facts about differences in musical and unmusical minds. The question may, therefore, be answered, first, with reference to our account of musical talent, showing that one person may have two, five, ten, fifty, one hundred, or even two hundred times the capacity that another has in a certain musical talent; that success in music depends upon the possession of essential talents; that the proportion of musical talent must be judged with reference to other fortes and faults of mind and body; that actual talent or lack of talent in the untrained child determines permanent traits in the musician; that we cannot make superior talents out of base talents; and that we should not build river bridges of silver and gold.

Reply personal. To those who are not trained in psycho-

logical analysis, the question is in a way unfair. It is like asking of one not trained in chemistry if he recognizes the magnitude and significance of chemical reactions. Yet, to represent a personal opinion, the answer should be based upon first-hand experience and personal insight. Emphasis rests upon the two words "magnitude" and "significance": Do I realize the magnitude and significance of individual difference in music?

2. Do I believe in giving each individual pupil in music an opportunity commensurate with his actual capacity and aptitude?

Bed-rock belief. This is merely a question of faith: Do I believe? The story is told of a woman who believed that she could move mountains by faith. One morning she started out to move a mountain in the neighborhood. She marched with firm step, saying, "I believe, I believe, I believe," until she dashed up against the face of the mountain and bounded back exclaiming, "That is just what I thought." The question pertains to what we actually think rather than to what we profess. Is the conviction so firmly ingrained that we think it when actually put to the test?

The corruption of democracy. The doctrine of democracy often results in great educational corruption. From certain universally admitted declarations of equality we derive the maxim: Treat all alike. From this the educator takes his cue and imposes upon the community the education doctrine: Make all alike. This doctrine finds great following because it can be administered by smooth and conventional machinery. But it is vicious because it results in decadence and suppression of the best forces in society. One result of this movement is the worship of classification

and ranking. We pat ourselves with pride when we have tied up the free and exuberant youth in educational lock-step. Like the Pharisees of old, we adulate ourselves that we are so exemplary.

Believe two things. An affirmative reply to this question asserts a belief in the wisdom and justice of two propositions: first, that the pupil in music has a right to expect that the instruction and training shall be adapted to his personal nature, which we have called above his personal equation; second that, other things equal, a musically talented person should have musical advantages proportional to his talent. The affirmative answer does not go so far as to affirm what many of us believe, that musical advantages should be more than proportional to the magnitude of the talent of the highly gifted, and that those who are markedly delinquent in musical capacities might be better off with less than proportional training. We can secure no action upon the first principle of educational psychology until educators believe in its justice and worth from the humanitarian, the economic, and the artistic points of view.

3. Do I actually, in practice, give my pupils an opportunity to grow, each according to his talent?

Where we may fail. This question is quite as relevant for private instruction as for class work. The teacher may not be capable of evaluating the qualities of the pupil; he may have a system applied equally to all; he may be a specialist in a field for which the pupil is not adapted; he may have an ambition to make every pupil like himself; he may not have grasped the principle of education through self-expression.

In the schoolroom. The relevance of the question with reference to class work is more patent. Face the issue in

the public schools squarely. Why should children be classified in music on the basis of arithmetic, geography, and history, that is, through regular classification by grades? A visitor to one of the middle grades will find that one fourth of the pupils are beyond the stage of instruction of the class and the exercise serves as a deadening of the best sensibilities and enthusiasms. One fourth of the class are not capable of comprehending or performing the task in hand, but sit listless and helpless and rightly regard themselves as unjustly abused. The members of the remaining one half of the class represent a variety of conditions, but most of them are capable of profiting to some extent by the exercises. The future musicians are all in the upper quarter of the class and suffer injustice musically in proportion to the actual magnitude of their musical talents.

A problem of the curriculum. This is a problem of the curriculum. Fortunately a few public schools have responded to the situation, but on the whole it remains inflexible and unfair. In round numbers it is safe to say that one fourth of the makers of the curriculum do not see the real problem. One fourth of those who see it do not believe in the rights of the individual as defined above, and one fourth of those who see it lack the ingenuity for devising a "system" to meet the situation. It will be interesting to know how high the remainder of the makers of the curriculum would rank themselves in answer to this question. Have no mercy on the educator who prides himself that he has made all alike, because it has not been done by making the unmusical musical, but by the suppression of the fit and most promising. Community singing has a place in school. Raising of the common level is worth while. Our appeal, however, is not for the lessening of instruction

to the mediocre, but for the freeing of the musically talented into a musical atmosphere in which they can grow and grow with joy in the comradeship of art.

4. Do I keep the pupil always at the highest level of achievement?

A profound educational policy. In studying, a few years ago, the provision for the care of the higher grade of feeble-minded the author found a certain institution in which it could be said that the children were happy, useful, and good. An inquiry into the organization of that institution revealed that it was because each child was kept at his highest level of achievement. Many of these mentally bereaved children had come from good homes in which they had been made unhappy, useless, and vicious because they had not been kept busy or because unreasonable tasks had been imposed upon them; but in this institution the capacities of each child had been determined as a basis for the assignment of tasks and privileges. This principle for the care of the defective child applies with more force to the normal child in an art. Keep the child busy at his highest level of achievement in music and he will be happy, useful, and good. To be at his best level of achievement he must be within his field of achievement.

5. Do I justly praise or blame the pupil?

The curse of false standards of achievement. The feeble-minded failed in their homes largely because they lost heart by being impressed at every turn by the fact of their worthlessness. A very large percentage of normal children have their hearts rent by persistent discouragement and nagging, or even by a superior attitude of aloofness or scorn on the ground that they should do this particular thing as well as other children do, while, as a matter of fact, the task is for

them a biological impossibility. The discouragement results in a vicious circle of negativism and a loss of self-control, and the feeling of worthlessness spreads into all sorts of maladjustments. On the other hand, the bright child is often praised unduly and made to feel that he is successful when he has come up to the average of the group, whereas he deserves no praise until he has come up to the average of those who are endowed as he is. He has been given a false standard.

6. *Do I rightly identify the retarded child?*

The bright child is the "retarded." The spirit of the Good Samaritan goes out rightly to help those who are in distress, those who are popularly regarded as retarded. But who is the retarded child? Strayer well says it is the bright child. The retarded child in public school music is the musically brilliant child who is entitled to instruction and association with those who are musical, but who is being held back and deprived of the stimulus which comes from the keenest social competition.

A kindness to the dull child. This retardation is often defended on the ground that it is good for the less gifted child to be associated with the highly gifted, but the reverse is the truth. The less gifted child is humiliated and discouraged by enforced association with those who are not at all in his class. He refuses to be patronized. He insists on the right to receive instruction at his own level and will respond when the instruction is adapted to him and his kind. It is now a recognized principle in vocational selection for business or industry that it is a genuine kindness to keep out of an occupation those who are not adapted for it, because it protects them against failure, and the rejection becomes a means of stimulating them to find some of the countless occupations for which they are qualified.

7. *Do I motivate my work for each individual?*

One of the classic punishments in penal history is to make a man carry a little brick back and forth from one wall to another throughout the day without any purpose. The musical purpose of one child is not the musical purpose of another. The musical outlet of one child is not the musical outlet of another. Children are as varied as are trees. Each tree prospers in its own type of culture. From the very first, the music pupil should be so placed, if accepted, that he is made to feel himself a part of the living art which takes hold of him and needs no device for stimulation, and that the work which is of foundation character shall be for him a gracious privilege. This is not merely the doctrine of interest. It is not a catering to the whim of the child. It is simply basing the venture upon an inventory of the equipment.

8. *Do I help my pupil to find himself?*

When the pupil is to launch himself in a career or in the rôle of an amateur artist, he must run the gantlet of the grim, unmerciful process of a struggle for survival. In the spirit of the first principle of educational psychology this difficulty should be met very much earlier before the serious musical education has been begun, and should remain persistently in the mind of the teacher throughout the instruction. To what extent does the teacher assume responsibility for this process of ascertaining whether or not the child is prepared for a successful career or — what is much commoner, and quite as important — an avocation which shall give both him and his friends genuine pleasure? In its happiest forms this sympathetic and thoughtful guidance results in the giving of a vision or an inspiration for music.

9. Do I take into account the individual as a whole, — bodily, social, intellectual, moral, æsthetic, and religious?

The child has several selves: the bodily, intellectual, moral, social, æsthetic, and religious. To what extent do our schemes for musical instruction take this fact into account? Is the music program built around this whole group of selves which constitute the individual, or is it conceived as a narrow technical fad, or catering to unguided impulses? Is the music program conceived in relation to its true educational significance for the development of the individual as a whole?

That should be our aim, for music as an educational means gives grace, suppleness, and vigor to the body; refines the intellect; enhances personal charms in social value; invests moral ideals with an æsthetic glow; constitutes the content of one art and an æsthetic attitude for all art; and furnishes the most beautiful medium for the expression of devotion to man and God.

II. Use of the Measure of Musical Talent in the Schools

Assuming that we recognize the value of the analyzed rating of musical talents, and that a number of such measures are sufficiently in hand to make them readily available in the public school system, we face the problem of determining the place and rôle of such measurements.

A consulting supervisor of music. For the large cities the most natural solution is the employment of a consulting supervisor of music, who shall be given general charge of the organization of surveys, the adjustment of the curriculum for the introduction of the tests and exercises, the planning of follow-up work, the giving of individual counsel and more

intensive examinations, and the adjustment of groupings for instruction in the public schools on the basis of ascertained talent. In smaller cities, towns, and communities, we must trust to the leadership of some one or more teachers who take on these responsibilities in part in addition to their other duties.

Characteristics of good elementary tests. With the test material now available the first move should be to introduce group measures of musical hearing. These should comply with the following conditions: (1) that the tests shall be such as can be made in large groups; (2) that they shall be of such nature as practically to eliminate the effect of practice and training, age, and degree of normal intelligence; (3) that they shall be as nearly "fool-proof" as possible, both for the manner of taking the record and the principles of its interpretation and application; (4) that they shall be of such a nature as to be doubly justified (*a*) for the information gathered, and (*b*) for the instruction gained through critical training furnished in the hearing of musical effects.

The six measures of musical hearing now available which comply with these conditions are (1) the sense of pitch, (2) the sense of intensity, (3) the sense of time, (4) the sense of consonance, (5) musical memory, and (6) musical imagery; all but the last are on phonograph records and a "Manual of Instructions" is furnished with the records. Directions for the test of musical imagery are found in Chapter XI. To these, new exercises and tests will undoubtedly be added from time to time, and they will be given a permanent place in the music course.

Each of these six test exercises has been so arranged that a quantitative measure can be obtained in a half-hour period. The series will, therefore, require three hours in all. These

exercises should be made a part of the regular musical instruction for the year and may be used in a variety of ways for the elucidation of the factors which enter into musical appreciation. These six tests may be employed for a dragnet survey of capacities for the hearing and appreciation of music.

Group measurements in the fifth grade. We have found that the fifth grade is the best stage for this survey because the children, as a class, are able to take a responsible attitude at that age, and it is early enough to start them in a musical education in case it may have been neglected up to that time. All who have good musical talent can be measured reliably at that age, but those who make poor records must be treated with reserve as in that grade several factors may operate to produce low marks. However, far more than half the children can be rated permanently on the basis of the showing made in the fifth grade where the test is carefully done.

Group measurements in the eighth grade. The child faces another turning point in the eighth grade. Here a limited group will transfer to the high school and trade schools and enter upon a new adjustment of studies marked by the beginning of elections. The majority will, however, leave school to work, and the avocation for life is probably chosen more frequently in this pre-adolescent year than in any other year. For both of these classes of pupils the claims of music, particularly as an avocation, should be presented in the most attractive form and on specific knowledge about natural endowment of the pupil for music.

It is, therefore, recognized that these six tests, and others which may be added from time to time, should be repeated in the eighth grade throughout the city. The record will serve as an effective reminder to those whose talents were

revealed in the fifth grade, and by this time those who, for lack of understanding or power of concentration, were unable to do themselves justice in the fifth grade, can be rated with certainty.

Analyzed ratings in the eighth grade. In addition to these measurements we should have, at this stage, an analyzed rating by teachers which might be the result of gradually accumulating observations and records of performances in the entire class in the grammar school. This should embrace primarily sight-reading, voice register, quality of voice, and record and rating of musical activities, musical interests, and musical progress.

With these two sets of data in hand some one qualified to speak should interview the children, and counsel with them in a sympathetic and constructive way, which should start the talented ones in the new career with the right aspirations for music.

Individual measurements of specific musical talents. Selected cases of exceptional talent, and particularly those who have ambition to enter upon a musical career, should, wherever facilities present themselves in the future, be given a more thorough examination such as that which was illustrated in Chapter I. On that point we must, of course, go slowly and have patience until the universities of the country shall be equipped for the training of such experts to meet the demands. The great danger which we shall face for years to come in this field is the danger of imposition by charlatans. The teaching profession in music is itself not standardized; there is much imposition. But this art of examining is a field in which practitioners will not be licensed for many years, and in which the ordinary public has no adequate conception of standards. It may, however,

be laid down as a rule that no one should be consulted for the analysis of musical talent who does not hold a good name and record in the musical profession, and can show evidence of adequate training in applied psychology. A sound knowledge of the human mind is absolutely necessary for one who shall offer counsel on the basis of analysis of talent. That understanding and appreciation of music are necessary is self-evident.

Intensive drill exercises. The material contained in the "Measures of Musical Talent" and the material suggested by these, which can be used to supplement them, may be employed to excellent advantage in the teaching of musical appreciation, and particularly to pedagogical advantage in the "bringing up" of laggards who have a musical ear and for some reason have failed to exercise it. Our manuals of musical instruction will undoubtedly be improved in the future from this point of view.

Guidance and encouragement. Except for the pedagogical value of the exercises, there is no object in making these measurements unless they are to be taken into account for the counsel and discriminating encouragement of children, parents, and music teachers. There is no one way in which this can be accomplished. Different methods must be followed in different schools according to the personalities of teachers and supervisors and the prevailing activities in the city. Those who have not had experience can hardly realize the thrill of satisfaction that comes to pupils and parents when objective evidence of high talent is presented. This is true of the talent which has been known and appreciated before, but is more strikingly true where the talent was discovered entirely by the records. For the youth who contemplates a serious musical career, a thorough inventory

may be of untold value in furnishing a quantitative indication of the probable prospect of achievement in music.

Discovery and sorting of pupils for musical activities. When surveys of this kind are made a part of the regular work in music in the fifth and eighth grades of the public schools as is recommended, we shall have a sort of universal dragnet for the preliminary discovery of rare talent which would otherwise be wasted. The tests in the eighth grade should be of special service as such dragnets for the finding of material for orchestras, glee clubs, choruses, etc. There is not the slightest doubt but that a very large percentage of children now not interested in such activities may be encouraged and enthused by such credentials as the talent records may afford. This encouragement should reach out into social, community, and church life.

Basis of admission to music schools. The music teacher may or may not be interested in making actual tests of talent a condition for admission to the music school, but, when once the pupil has entered, there can be no debate as to the desirability of a quantitative analysis and rating of talents for the purpose of determining the type of musical education for which the pupil is best fitted.

Function of the measures in the music school. From the point of view of raising standards of a school and advertising them much is to be said in favor of the selection of promising pupils, and restriction to them. But the fairer and more logical procedure is to make as full talent analysis as possible at the time of the entrance of the pupil, and to place the facts fairly and squarely before the pupil and the patron in order that teacher and pupil may be guided by this inventory in the planning of the character and the extent of the music course. This is a procedure to which all well-

organized music schools must ultimately come, for it is of far greater significance than the inventory of the pupil's financial status which now plays a recognized rôle.

The discovery and remedy of difficulties. The tests may also serve a sort of clinical purpose in that persons who have entered seriously upon a musical education and have struck difficulties may have the situation analyzed and diagnosed so that the exact nature of the difficulty may be known, and the teacher may proceed with knowledge, not only as to what the difficulty is but also as to whether or not it can be remedied.

III. Organization of the Musical Schedule in the Grades on the Basis of Ability to Progress and Profit

The present prevailing method of classifying pupils for instruction in music on the basis of age or achievement in arithmetic or history, must soon become obsolete, because it is a gross violation of the first principle of educational psychology; namely, "*Keep the child busy at his highest level of achievement.*"

The classification should be based upon the rating of children on progress in singing or other music, supplemented by the rating obtained in the before-mentioned tests. The tests may draw out many cases of specific and superior ability which remain latent under the old non-competitive system.

Justice and help to the child of inferior musical endowment. The old method is not only shamefully wasteful in time, but it has a demoralizing effect upon talented and untalented child alike. All admit that it is not good for a child who is superior in singing to be held in leash by an artificial classification. It is not so generally known, but it can be

demonstrated beyond question, that psychologically the effect of such alignment is always bad for the child of inferior musical endowment. If the training is above his level, it creates a feeling of self-depreciation and disgust, and it fails to give the child that musical stimulus which can reach him. The old argument that it is good for the inferior singer to be trained with the superior singer is false, both from the point of view of economy of time and from the point of view of the development of musical appreciation and the will to achieve. The classification of children in the grades for technical instruction in music must be based upon the capacity for achievement in such music — not on arithmetic, sight reading, or age. This is a fundamental proposition. It is the first unequivocal demand of educational psychology. It is humane.

Voluntary organizations. These requirements may be partly fulfilled through the generous maintenance of voluntary organizations, both vocal and instrumental, for all grades. It is manifest that the efficiency gained by such voluntary training should be recognized by promotion in the regular training course, whether taken in study hours or outside. Likewise, the efficiency gained through private instruction should be recognized in the classification for regular training.

Flexible curriculum. However, compliance with these principles requires a flexibility in the grouping for musical instruction in all grades from the primary upward, which is a serious problem in administration. There are two ways of meeting that situation. One is to provide the music at such hours for the different groups that there can be the greatest freedom of crossing class lines. For example, some of the third grade pupils may be assigned to the fourth

grade in singing, and some fourth grade pupils may be held back even in the first grade until the standards of the grade have been met. If promotion is based primarily upon the ability to sing, the sight reading can be learned rapidly by pupils who have ability and interest in music. Standards for sight singing should not be lowered; however, sight reading in itself is not music.

Recognizing both age and ability. But this system of promotion does not meet the real need. It still keeps the musical and unmusical tied together and increases the humiliation of those who progress very slowly. The real purpose should be to bring together, as nearly as possible, those of the same degree of natural musical ability. The true solution, both in economy of time and efficiency of achievement, may be gained by carrying, either for each grade, or preferably for a small group of grades, three divisions, roughly as follows: the superior twenty-five per cent, the middle fifty per cent, and the inferior twenty-five per cent, with continual shifting from one division to another as merit may warrant. This, with free promotion or demotion, would make a happy solution.

But there is no universal solution for this program shift. Each superintendent and principal must find a solution adapted to the needs and resources of the school. The solution does not lie in mere promotion. It should be the function of the supervisor of music to be in frequent conference with makers of programs and teachers of music for the purpose of developing a flexible system in the grades which shall comply with the twofold slogan: classification and promotion in singing on the basis of ability to sing; and, musical advantages proportional to musical talent.

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